TÜV RHEINLAND
ENERGIE UND UMWELT GMBH

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-11120-02-00

Report on the performance testing of the Serinus 40 ambient air quality monitoring system manufactured by Ecotech Pty Ltd measuring NO, NO_2 and NO_x

TÜV Report: 936/21221977/A_EN
Cologne, 08 October 2013

www.umwelt-tuv.de

teu-service@de.tuv.com

The department of Environmental Protection of TÜV Rheinland Energie und Umwelt GmbH
is accredited for the following work areas:

- Determination of air quality and emissions of air pollution and odour substances;
- Inspection of correct installation, function and calibration of continuously operating emission measuring instruments, including data evaluation and remote emission monitoring systems;
- Combustion chamber measurements;
- Performance testing of measuring systems for continuous monitoring of emissions and ambient air, and of electronic data evaluation and remote emission monitoring systems;
- Determination of stack height and air quality projections for hazardous and odour substances;
- Determination of noise and vibration emissions and pollution, determination of sound power levels and execution of sound measurements at wind energy plants

according to EN ISO/IEC 17025.

The accreditation is valid until 22-01-2018. DAkkS-register number: D-PL-11120-02-00.

TÜV Rheinland Energie und Umwelt GmbH
D - 51105 Cologne, Am Grauen Stein, Tel: +49 221 806-5200. Fax: +49 221 806-1349

Blank page

DAkkS Deutsche Akkreditierungsstelle D-PL-11120-02-00

Report on the performance testing of the Serinus 40 ambient air quality monitoring system manufactured by Ecotech Pty Ltd measuring NO, NO_2 and NO_x

Instrument tested: Serinus 40

Manufacturer: Ecotech Pty Ltd
1492 Ferntree Gully Road
Knoxfield VIC Australia 3180
Australia

Test period: April 2013 to October 2013

Date of report: 08 October 2013

Report number: 936/21221977/A_EN

Editor: Dipl.-Ing. Guido Baum
Tel.: ++49 221 806-2592
guido.baum@de.tuv.com

Scope of report:

Report		122	pages
Manual	page	122	et seq.
Manual	of	138	pages
Total		260	pages in total

Blank page

Contents

List of tables

List of figures

Blank page

1. Summary and certification proposal

1.1 Summary

Ecotech Pty Ltd has commissioned TÜV Rheinland Energie und Umwelt GmbH to carry out performance testing of the Serinus 40 measuring system for the components NO, NO_2 und NO_x.

Testing was performed in compliance with the following standards and guidelines:

- VDI Guideline 4202 Sheet 1: Performance criteria for performance tests of automated ambient air measuring systems; Point-related measurement methods for gaseous and particulate air pollutants, September 2010
- VDI Guideline 4203 Sheet 3: Testing of automated measuring systems; Test procedures for point related ambient air measuring systems for gaseous and particulate air pollutants, September 2010
- DIN EN 14211: Ambient air – Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence, November 2012

The Serinus 40 measuring system uses the method of chemiluminescence, which serves as a reference method in the EU, to measure the components NO, NO_2 and NO_x. Tests were performed in the laboratory as well as during a three month field test in Cologne. The measured ranges were as followed:

Table 1: Measured ranges during testing

Measured component	Measured range in [µg/m³] [1)]	Measured range in [ppb] or [nmol/mol]
NO_2	0 – 500	0 – 261
NO	0 – 1200	0 – 962

[1)] The data refer to 20°C and 101.3 kPa.

Minimum requirements were met during performance testing.

TÜV Rheinland Energie und Umwelt GmbH therefore suggests its type approval for continuous measurement of nitrogen dioxide concentrations in ambient air.

1.2 Certification proposal

Due to the positive results achieved, the following recommendation is put forward for the notification of the AMS as a type-approved measuring system:

AMS designation:

Serinus 40 for NO, NO_2 and NO_x

Manufacturer:

Ecotech Pty Ltd, Knoxfield, Australia

Field of application:

Continuous measurement of nitrogen dioxide concentrations in ambient air from stationary sources.

Measured ranges during performance testing:

Component	Certification range	Unit
Nitrogen monoxide	0 - 1200	µg/m³
Nitrogen dioxide	0 - 500	µg/m³

Software version:

Firmware: 2.09.0005

Restrictions:

none

Notes:

1. The measuring system has to be operated in a lockable measuring cabinet or container.
2. The test report on the performance test is available online at www.qal1.de.

Test report:

TÜV Rheinland Energie und Umwelt GmbH, Cologne

Report no.: 936/21221977/A_EN dated 08 October 2013

1.3 Summary of test results

Performance criterion	Minimum requirement	Test result	Compliance	Page
4 Requirements on the instrument design				
4.1 General requirements				
4.1.1 Measured value display	Shall be available.	The measuring system is fitted with a measured value display.	yes	34
4.1.2 Easy maintenance	Necessary maintenance of the measuring system should be possible without larger effort, if possible from outside.	Maintenance can be carried out with usual tools in a reasonable time and from the outside.	yes	35
4.1.3 Functional check	If the operation or the functional check require particular instruments, they shall be considered as part of the measuring system and be applied in the corresponding sub-tests and included in the assessment.	The instrument tested does not have an internal device for functional checks.	not applicable	36
4.1.4 Set-up times and warm-up times	The set-up times and warm-up times shall be specified in the instruction manuals.	Set-up times and warm-up times were determined.	yes	37
4.1.5 Instrument design	The instruction manual shall include specifications of the manufacturer regarding the design of the system.	The specifications of the manual with regard to instrument design are complete and correct.	yes	38
4.1.6 Unintended adjustment	It shall be possible to secure the adjustment of the measuring system against illicit or unintended adjustment during operation.	The measuring system itself is not protected against the unintended or unauthorised adjustment of instrument parameters. It has to be operated in a lockable measuring container.	no	39
4.1.7 Data output	The output signals shall be provided digitally and/or as analogue signals.	Measured signals are provided in analogue (0-20 mA, 2-20 mA, 4-20 mA or 0-5 V) and digital form (via TCP/IP, RS232, USB; Bluetooth).	yes	40

Performance criterion	Minimum requirement	Test result	Com-pliance	Page
5. Performance characteristics				
5.1 General	The manufacturer's specifications in the instruction manual shall be by no means better than the results of the performance tests.	No discrepancies between the instrument design and the instruction manuals were observed.	yes	41
5.2 General requirements				
5.2.1 Certification range	Shall meet the requirements of Table 1 of VDI Guideline 4202 Sheet 1.	The measuring system can be assessed in the range of the relevant limit values.	yes	42
5.2.2 Measuring range	The upper limit of measurement of the measuring systems shall be greater or equal to the upper limit of the certification range.	By default the measuring range is set to 0 – 500 µg/m³ for NO_2. Other measuring ranges of max. 0 – 20 ppm are possible. The upper limit of the measuring range is larger than the respective upper limit of the certification range.	yes	43
5.2.3 Negative output signals	May not be suppressed (life zero).	The measuring system also displays negative measured values.	yes	44
5.2.4 Failure in the mains voltage	In case of malfunction of the measuring system or failure in the mains voltage, uncontrolled emission of operation and calibration gas shall be avoided. The instrument parameters shall be secured by buffering against loss. When mains voltage returns, the instrument shall automatically reach the operation mode and start the measurement.	When mains voltage returns the measuring system goes back to a failure-free operational status and automatically resumes measuring.	yes	45
5.2.5 Operating states	The measuring system shall allow the control of important operating states by telemetrically transmitted status signals.	By means of various connectivity options and the "Serinus Downloader" software the measuring system can be monitored and controlled from an external PC.	yes	46
5.2.6 Switch-over	Switch-over between measurement and functional check and/or calibration shall be possible telemetrically by computer control or manual intervention.	In general, all necessary tasks related to functional checks may be performed directly on-site or monitored telemetrically using the remote control functions.	yes	47
5.2.7 Maintenance interval	Preferably 3 months but at least 2 weeks.	As determined by the necessary maintenance tasks the maintenance interval is 4 weeks.	yes	48

Performance criterion	Minimum requirement	Test result	Compliance	Page
5.2.8 Availability	At least 95 %.	Availability for both systems was 100 % incl. maintenance times during testing.	yes	49
5.2.9 Instrument software	Shall be displayed during switch-on of the measuring system. The test institute shall be informed on changes in the instrument software, which influence the performance of the measuring system.	The instrument software version is indicated in the display. Changes to the software will be communicated to the test institute.	yes	50
5.3 Requirements on measuring systems for gaseous air pollutants				
5.3.1 General	Minimum requirements as per VDI Guideline 4202 Sheet 1.	The tests were performed on the basis of the minimum requirements as stipulated in VDI 4202 Sheet 1 (September 2010) as well as Standard DIN EN 14211 (2012).	yes	51
5.3.2 Repeatability standard deviation at zero point	The repeatability standard deviation at zero point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010) in the certification range specified in Table 1 of the same guideline.	Please refer to section 7.1 8.4.5 Repeatability standard deviation.	yes	52
5.3.3 Repeatability standard deviation at reference point	The repeatability standard deviation at reference point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010) in the certification range according to Table 1 of the same guideline.	Please refer to section 7.1 8.4.5 Repeatability standard deviation.	yes	53
5.3.4 Linearity (lack of fit)	The analytical function describing the relationship between the output signal and the value of the air quality characteristic shall be linear.	Please refer to section 7.1 8.4.6 Lack of fit of linearity of the calibration function.	yes	54
5.3.5 Sensitivity coefficient of sample gas pressure	The sensitivity coefficient of sample gas pressure at reference point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.4.7 Sensitivity coefficient to sample gas pressure.	yes	55

Performance criterion	**Minimum requirement**	**Test result**	**Com-pliance**	**Page**
5.3.6 Sensitivity coefficient of sample gas temperature	The sensitivity coefficient of sample gas temperature at reference point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 (September 2010).	Please refer to section 7.1 8.4.8 Sensitivity coefficient to sample gas temperature.	yes	56
5.3.7 Sensitivity coefficient of surrounding temperature	The sensitivity coefficient of surrounding temperature at zero and reference point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.4.9 Sensitivity coefficient to the surrounding temperature.	yes	57
5.3.8 Sensitivity coefficient of supply voltage	The sensitivity coefficient of supply voltage shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.4.10 Sensitivity coefficient to electrical voltage.	yes	58
5.3.9 Cross-sensitivity	The change in the measured value caused by interfering components in the sample gas shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010) at zero and reference point.	Please refer to section 7.1 8.4.11 Interferents.	yes	59

Performance criterion	Minimum requirement	Test result	Compliance	Page
5.3.10 Averaging effect	For gaseous components the measuring system shall allow the formation of hourly averages. The averaging effect shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.4.12 Averaging test	yes	60
5.3.11 Standard deviation from paired measurements	The standard deviation from paired measurements under field conditions shall be determined with two identical measuring systems by paired measurements in the field test. It shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.5.5 Reproducibility standard deviation for NO_2 under field conditions.	yes	61
5.3.12 Long-term drift	The long-term drift at zero point and reference point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010) in the field test.	Please refer to section 7.1 8.5.4 Long term drift.	yes	62
5.3.13 Short-term drift	The short-term drift at zero point and reference point shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010) within 12 h (for benzene 24 h) in the laboratory test and within 24 h in the field test.	Please refer to section 7.1 8.4.4 Short-term drift .	yes	63
5.3.14 Response time	The response time (rise) of the measuring system shall not exceed 180 s. The response time (fall) of the measuring system shall not exceed 180 s. The difference between the response time (rise) and response time (fall) of the measuring system shall not exceed 10 % of response time (rise) or 10 s, whatever value is larger.	Please refer to section 7.1 8.4.3 Response time.	yes	64

Performance criterion	Minimum requirement	Test result	Compliance	Page
5.3.15 Difference between sample and calibration port	The difference between the measured values obtained by feeding gas at the sample and calibration port shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.4.13 Difference sample/calibration port.	yes	65
5.3.16 Converter efficiency	In case of measuring systems with a converter, the converter efficiency shall be at least 98 %.	Please refer to section 7.1 8.4.14 Converter efficiency.	yes	66
5.3.17 Increase of NO_2 concentration due to residence in the measuring system	In case of NO_x measuring systems the increase of NO_2 concentration due to residence in the measuring system shall not exceed the requirements listed in Table 2 of VDI Guideline 4202 Sheet 1 (September 2010).	Please refer to section 7.1 8.4.15 Residence time in the analyser.	yes	67
5.3.18 Overall uncertainty	The expanded uncertainty of the measuring system shall be determined. The value determined shall not exceed the corresponding data quality objectives specified in the applicable EU Directives on air quality as listed in Annex A, Table A 1 of VDI Guideline 4202 Sheet 1 (September 2010).	The determination of uncertainty was performed in accordance with DIN EN 14211 (2012) and is detailed in section 7.1 8.6 Total uncertainty in accordance with Annex E of DIN EN 14211 (2012).	yes	68
8.4 Requirements of Standard DIN EN 14211				
8.4.3 Response time	Neither the response time (rise) nor the response time (fall) shall exceed 180 s. The difference between rise and fall response time shall not exceed 10 s.	The maximum permissible response time of 180 s is exceeded at no time. The maximum response time determined for system 1 is 35 s for NO and 33 s for NO_2. The maximum response time determined for system 2 is 36 s for NO and 31 s for NO_2.	yes	69

Performance criterion	Minimum requirement	Test result	Compliance	Page
8.4.4 Short-term drift	The short-term drift at zero shall not exceed 2.0 nmol/mol/12h (i.e. 2.50 µg/m³/12h). The short-term drift at span level shall not exceed 6.0 nmol/mol/12h (i.e. 7.50 µg/m³/12h).	The short term drift at zero is 0.0 nmol/mol for system 1 and 0.03 nmol/mol for system 2. The short-term drift at span point is -1.11 nmol/mol for system 1 and -0.48 nmol/mol for system 2.	yes	74
8.4.5 Repeatability standard deviation	The repeatability standard deviation shall neither exceed 1.0 nmol/mol (i.e. 1.25 µg/m³) at zero nor shall it exceed 3.0 nmol/mol (i.e. 3.75 µg/m³) of the test gas concentration at span point.	The repeatability standard deviation at zero point is 0.31 nmol/mol for system 1 and 0.19 nmol/mol for system 2. The repeatability standard deviation at span point is 0.27 nmol/mol for system 1 and 0.19 nmol/mol for system 2.	yes	78
8.4.6 Lack of fit of linearity of the calibration function	The lack of fit of linearity of the calibration function shall not exceed 5.0 nmol/mol (i.e. 6.3 µg/m³) at zero point and 4 % of the measured value at concentrations above zero.	For system 1, the deviation from the regression line is 0.46 nmol/mol at zero point and max. 0.72 % of the target value for concentrations greater than zero. For system 2, the deviation from the regression line is -0.22 nmol/mol at zero point and max. 0.84 % of the target value for concentrations greater than zero.	yes	80
8.4.7 Sensitivity coefficient to sample gas pressure	The sensitivity coefficient to sample gas pressure shall not exceed 8.0 nmol/mol/kPa (i.e. 10 µg/m³/kPa).	For system 1, the sensitivity coefficient to sample gas pressure is 1.29 nmol/mol/kPa. For system 2, the sensitivity coefficient to sample gas pressure is 1.97 nmol/mol/kPa.	yes	85

Performance criterion	**Minimum requirement**	**Test result**	**Compliance**	**Page**
8.4.8 Sensitivity coefficient to sample gas temperature	The sensitivity coefficient to sample gas temperature shall not exceed 3.0 nmol/mol/K (i.e. 3.75 µg/m³/K).	For system 1, the sensitivity coefficient to sample gas temperature is 0.04 nmol/mol/K. For system 2, the sensitivity coefficient to sample gas temperature is 0.45 nmol/mol/K.	yes	87
8.4.9 Sensitivity coefficient to the surrounding temperature	The sensitivity coefficient to the surrounding temperature shall not exceed 3.0 nmol/mol/K (i.e. 3.75 µg/m³/K).	The sensitivity coefficient to the surrounding temperature does not exceed the performance criteria of max. 3.0 nmol/mol/K. For both systems, the highest value bst is used for the purpose of evaluating uncertainty. For system 1 it is 0.62 nmol/mol/K and for system 2 it is 0.24 nmol/mol/K.	yes	89
8.4.10 Sensitivity coefficient to electrical voltage	The sensitivity coefficient to electrical voltage shall not exceed 0.30 nmol/mol/V (i.e. 0.38 µg/m³/V).	The sensitivity coefficient of electrical voltage bv does not exceed the performance criteria of max. 0.30 nmol/mol/V stipulated in Standard DIN EN 14211 at any point. For both systems, the highest value bv is used for the purpose of evaluating uncertainty. For system 1 it is 0.045 nmol/mol/V and for system 2 it is 0.006 nmol/mol/V.	yes	92
8.4.11 Interferents	Interferents at zero concentration and at a concentration c_t (at the level of the hourly limit value = 200 µg/m³ for NO_2). Maximum responses for the components H_2O, CO_2 and NH_3 are ≤ 5.0 nmol/mol (i.e. 6.25 µg/m³) each.	Cross-sensitivity at zero point is 0.09 nmol/mol for system 1 and -0.30 nmol/mol for system 2 for the component H_2O, -0.47 nmol/mol for system 1 and 0.60 nmol/mol for system 2 for the component CO_2, as well as 0.00 nmol/mol for system 1 and -0.24 nmol/mol for system 2 for the component NH_3. Cross-sensitivity at the limit value c_t is -0.03 nmol/mol for system 1 and 0.57 nmol/mol for system 2 for the component H_2O, 1.43 nmol/mol for system 1 and 0.43 nmol/mol for system 2 for the component CO_2 as well as 0.80 nmol/mol for system 1 and 1.41 nmol/mol for system 2 for the component NH_3.	yes	94
8.4.12 Averaging test	The influence of averaging shall not exceed 7 % of the instrument reading.	This is in complete compliance with the performance criteria stipulated in Standard DIN EN 14211.	yes	97
8.4.13 Difference sample/calibration port	The difference in response of the analyser to feeding through the sample or calibration port shall not exceed ≤1 %.	This is in complete compliance with the performance criteria stipulated in Standard DIN EN 14211.	yes	100

Performance criterion	Minimum requirement	Test result	Compliance	Page
8.4.14 Converter efficiency	The converter efficiency shall be at least 98 %.	This is in complete compliance with the performance criteria stipulated in Standard DIN EN 14211.	yes	102
8.4.15 Residence time in the analyser	The residence time inside the analyser shall not exceed 3.0 s.	The residence time inside the analyser is 2.4 s.	yes	103
8.5.4 Long term drift	The long-term drift at zero shall not exceed 5.0 nmol/mol (i.e. 6.25 µg/m³). The long-term drift at span level shall not exceed 5 % of the certification range (i.e. 13.05 µg/m³ in a measuring range of 0 to 261 nmol/mol).	The maximum long term drift at zero $Dl_{,z}$ is -0.51 nmol/mol for system 1 and 0.58 nmol/mol for system 2. The maximum long term drift at span point $Dl_{,s}$ is 2.51 % for system 1and 2.55 % for system 2.	yes	105
8.5.6 Period of unattended operation	The maintenance interval shall be at least 2 weeks.	The maintenance interval is subject to the necessary maintenance tasks and is 4 weeks.	yes	112
8.5.5 Reproducibility standard deviation for NO_2 under field conditions	The reproducibility standard deviation under field conditions shall not exceed 5 % of the average value over a period of 3 months.	The reproducibility standard deviation for NO_2 was 3.55 % of the average over a period of 3 months in the field. Thus, the requirements of Standard DIN EN 14211 are met.	yes	109
8.5.7 Period of availability of the analyser	The availability of the measuring system shall be at least 90 %.	The availability is 100 %. This complies with the requirements of Standard DIN EN 14211.	yes	113

2. Task definition

2.1 Nature of the test

Ecotech Pty Ltd has commissioned TÜV Rheinland Energie und Umwelt GmbH to carry out performance testing of the Serinus 40 measuring system. The test was a complete performance test.

2.2 Objective

The instrument is designed to measure the concentrations of NO, NO_2 and NO_x in ambient air in the following concentration ranges:

Component	Certification range	Unit
Nitrogen monoxide	0 - 1200	µg/m³
Nitrogen dioxide	0 - 500	µg/m³

The Serinus 40 measuring system uses the chemiluminescence method to measure the components NO, NO_2 and NO_x.

Performance testing was to be carried out in accordance with current standards taking into consideration the latest developments.

Testing was performed on the basis of the following standards and guidelines:

- VDI Guideline 4202 Sheet 1: Performance criteria for performance tests of automated ambient air measuring systems; Point-related measurement methods for gaseous and particulate air pollutants, September 2010
- VDI Guideline 4203 Sheet 3: Testing of automated measuring systems; Test procedures for point related ambient air measuring systems for gaseous and particulate air pollutants, September 2010
- DIN EN 14211: Ambient air – Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence, November 2012

3. Description of the analyser tested

3.1 Measuring principle

The Serinus 40 measuring system continuously monitors concentrations of nitrogen oxides by means of the chemiluminescence method. The instrument is designed for the continuous measuring of NO, NO_2 and NO_x in ambient air.

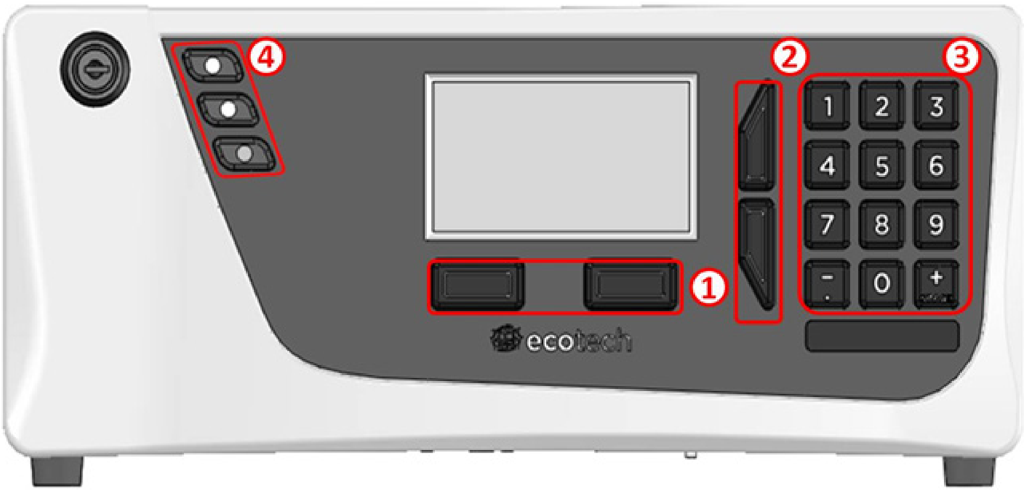


Figure 1: Representation of the Serinus 40 analyser

Nitric oxides are measured on the basis of chemiluminescence detection of gas phases. Sample air enters the reaction cell via two separate (alternating) paths; the NO and NO_X channels.

In the first path, NO reacts with ozone as follows:

$$NO + O_3 \rightarrow NO_2^* + O_2$$

In the second path, the gas first passes through the delay coil and then through the NO_2/NO converter so that it reaches the reaction cell after the gas in the first path. At that time NO_X (total concentration of NO and NO_2) is measured.
The NO_2 concentration is then calculated by subtracting the NO value from the measured NO_X value.

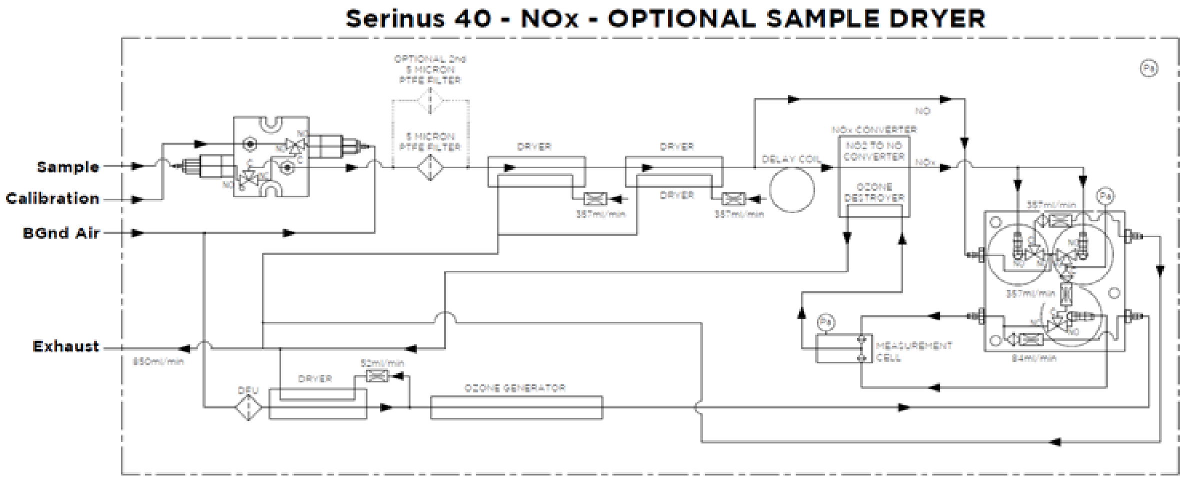


Figure 2: Pneumatic circuit diagram with permeation dryer in the sample gas line as tested during performance testing

This reaction releases energy in the form of chemiluminescent radiation at a wavelength of 1100 nm, which is filtered by the optical band-pass filter and detected by the photomultiplier tube (PMT).

The detected level of chemiluminescence is directly proportional to the NO concentration in the sample.

The NO_2 concentration is calculated by subtracting the NO value from the measured NO_X value:

$$NO_X = NO + NO_2$$
or
$$NO_2 = NO_X – NO$$

3.2 Analyser scope and set-up

The Serinus 40 Oxides of Nitrogen Analyser consists of five main modules:

- pneumatics for passing on sample and exhaust gas (incl. valve manifolds)
- sensors for measuring nitrogen oxides (reaction cell module) and other relevant parameters
- control unit consisting of printed circuit boards for the control of sensors and pneumatics
- power supply for all processes in the analyser
- communication module for data access

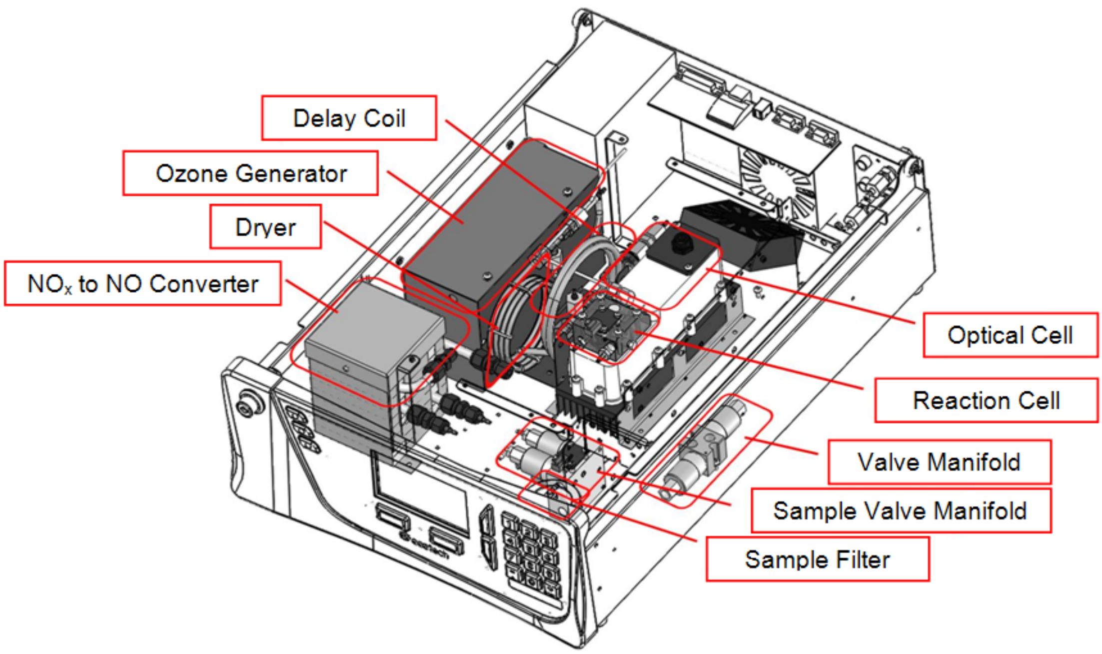


Figure 3: Internal components of the Serinus 40 measuring system

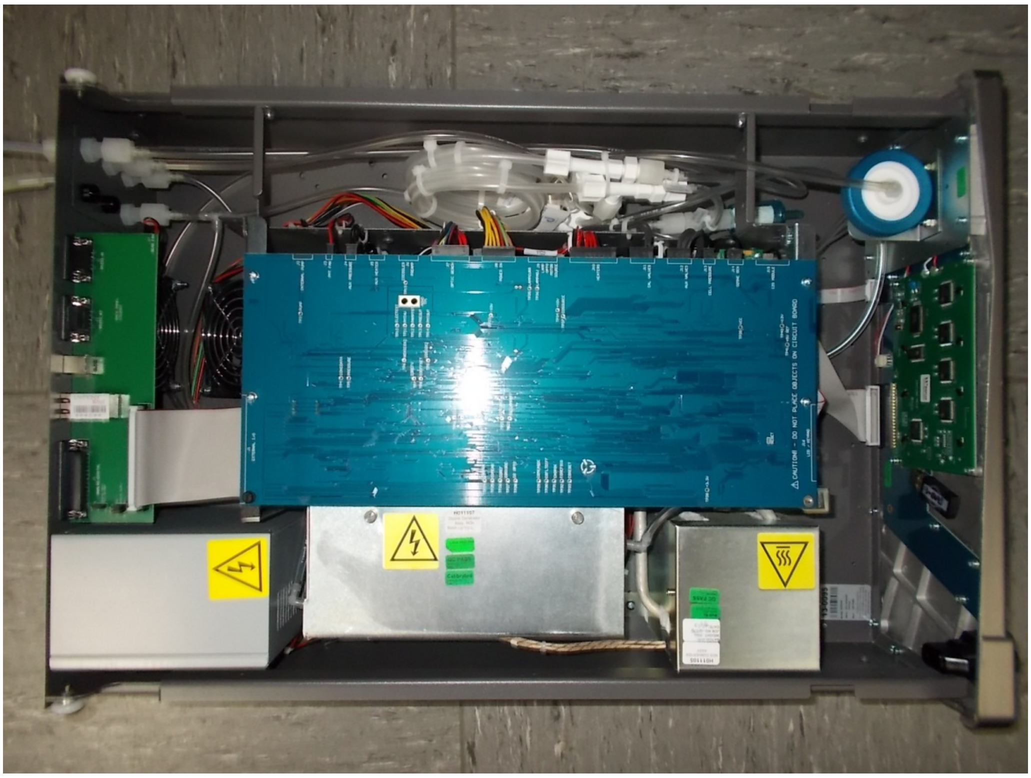


Figure 4: Internal view of the Serinus 40 measuring system

Particulate Filter

The particulate filter is a Teflon 5 micron (µm) filter with a diameter of 47 mm. This filter eliminates all particles larger than 5 µm that could interfere with sample measurements.

Permeation Dryer for Drying the Sample Gas

After the particle filter there are two serially-connected permeation dryers in the sample gas line. During performance testing, these dryers were integrated into the analyser and therefore shall be considered as part of the tested measuring system. The dryers remove moisture from the sample gas and thereby reduce the amount of interference caused by moisture.

Delay Coil

The delay coil is a loop of sample tubing which increases the amount of time the sample air needs to travel to the NO_2/NO converter and to the measuring cell. This delay allows a single sample to be split into the NO channel and the NO_X channel. Thus, a sequential measurement is possible without introducing a lag on the measurement of the NO_X channel, i.e. the NO_X sample is taken at the same time as the NO sample but measured after NO in the same cell.

Dryer

The dryer consists of Nafion tubing and was developed for the removal of water vapour from the ambient air used by the ozone generator. The walls of the tubing absorb the water and release it into the surrounding air. The remaining gas is not affected. The flow rate is regulated by means of a critical orifice.

Ozone Generator
The ozone generator is a corona discharge ozone source driven by an ignition coil. Dry air is drawn into the discharge tube via an orifice and then ionised by a high voltage electrode. This yields O_3 from the reaction 3O2 → 2O3. The ionisation takes place in the confines of a glass tube with the electrode mounted on the outside. The amount of ozone generated is controlled by varying the energy to the discharge tube. The ozone flow rate is approximately 80 cc/min with an ozone concentration of 6000 - 8000 ppm.

NO_2/NO Converter
The NO_2/NO converter uses high temperatures (325 °C) and a catalyst to convert any NO_2 in the sample to NO.
The NO_2/NO converter assembly also houses a catalytic ozone destroyer that removes ozone from the instrument exhaust.
To obtain accurate and stable results, the converter must operate at above 96 % (US EPA) or 95 % (Australian standard).

Sample Valve Manifold
The sample valve manifold switches between samples, calibration and background gas.

Auxiliary Valve Manifold
The auxiliary valve manifold switches sample gas between NO and NO_X channels along with background and bypass flow.

Pressure Transducers
Two pressure transducers are used for the calculation of sample flow rate. One is located upstream to the critical orifice (manifold pressure) and the other is located in the reaction cell downstream of the critical orifice (cell pressure).

Reaction Cell
The reaction cell is where ozone and NO mix to create a chemiluminescence reaction which emits radiation. A portion of this radiation is filtered to a specific wavelength (1100nm) and measured by the PMT.

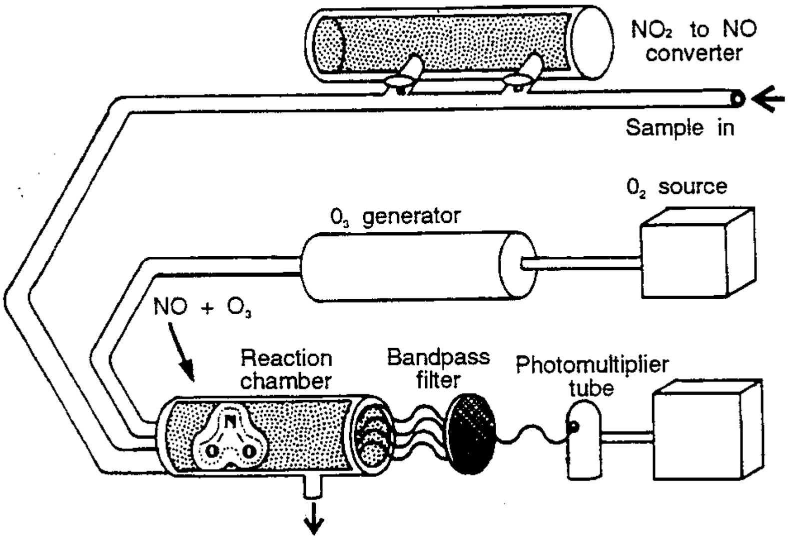


Figure 1 – Reaction cell operation

Optical Band-Pass Filter
The optical band-pass filter is constructed of coloured glass that only allows the transmission of light between 600 nm - 1200 nm.

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
The PMT cooler ensures that the PMT is operated at a constant 13° C. This reduces the noise of the PMT.

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.

Main Controller PCB
The main controller PCB controls all the processes within the instrument. It contains a battery backed clock, calendar and an on-board microprocessor. The main controller PCB is located on top of the other components within the analyser. The PCB pivots on hinges to allow access to the components underneath.

Power Supply
The power supply is a self-contained unit housed in a steel case.
It has a selectable input voltage of 115 or 230VAC 50/60 Hz and an output voltage of 12 VDC power for distribution within the analyser.

On/Off Switch
The on/off switch is located on the back panel (bottom right from behind the instrument).

Communications
The analyser can be connected to a data logger, a laptop computer or a network by means of the following communications connections located on the back panel of the instrument.

RS232 #1
This port is designed to be used for simple RS232 communication.

RS232 #2
This port is designed to be used for simple RS232 communication, or in multidrop configuration.

USB
This port is used for instrument communication. It allows for quickly downloading data, onsite diagnostics, maintenance as well as 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 analogue/digital port sends and receives analogue/digital signals to/from other devices. These signal are commonly used to activate gas calibrators or for warning alarms.

Analogue Outputs
The analyser is equipped with three analogue outputs. Menu selectable as either voltage output 0-5 VDC, or current output 0-20, 2-20, 4-20 mA.

Analogue Inputs
The analyser is also equipped with three analogue voltage inputs (0-5 VDC) with resolution of 15 bits plus polarity.

Digital Status Inputs
The analyser is equipped with 8 logic level inputs (0-5 VDC) for the external control of zero/span point calibration sequences.

Digital Status Outputs
The analyser is equipped with 8 open collector outputs which will convey instrument status conditions and warning alarms such as “no flow” or “sample mode”, etc.

Bluetooth
This allows for remote access of the analyser to any Android device with the "Serinus Remote" application installed on it. The application uses Bluetooth to control the analyser, view parameters, download data and construct real-time graphs.

Sample Gas Pump

Manufacturer: Thomas, type: 617CD22-194 C

During performance testing the above-mentioned sample gas pump was used in the laboratory as well as in the field test. As far as the models Serinus 10 (ozone), Serinus 30 (CO) and Serinus 50 (SO_2) are concerned, one pump can be operated with up to two analysers. However, for the Serinus 40 (NO_X) one sample gas pump per analyser is required.

Table 2 provides a list with important technical features of the Serinus 40 measuring system

Table 2: Technical data of the Serinus 40 (as provided by the manufacturer)

Measuring range:	Max. 0 – 20 ppm (programmable)
Unit:	ppb
Measured compounds:	NO, NO_2, NO_x
Sample flow rate:	approx. 0.6 litres/min
Output signals:	• USB port on the back side • Bluetooth (digital communication via Android Application) • TCP/IP Ethernet network connection (optional) • RS232 port #1: digital communication or termination panel connections • RS232 port #2: multidrop port used for multiple analyser connections on a single RS232 • USB flash memory (front panel) for data logging, event logging and parameters/ configuration storage
Protocols:	Modbus RTU/TCP, Bavarian, EC9800, Advanced
Power supply:	99 V – 132 V, 57 Hz – 63 Hz or 198 V – 264 V, 47Hz – 53 Hz
Consumption:	max. 265 W
Dimensions (L x B x H) / weight:	597 x 418 x 163 mm / 21.9 kg

4. Test programme

4.1 General remarks

Performance testing was carried out with two complete and identical instruments with the serial numbers

System 1: SN 13-0095 and
System 2: SN 13-0094.

During the test software version 2.09.0005 was implemented.

Performance testing consisted of a laboratory test to determine the performance characteristics and a field test that lasted several months.

This report presents a heading for each test criterion along with the number and description as stipulated in the respective standard [1. 2. 3. 4].

4.2 Laboratory test

The laboratory test was carried out with two identical Serinus 40 measuring systems with the serial numbers SN: 13-0095 and SN: 13-0094. In accord with the guidelines [2, 3] the following performance criteria were tested:

- Description of operating states
- General requirements
- Adjustment of the calibration line
- Short-term drift
- Repeatability standard deviation
- Sensitivity coefficient of sample gas pressure
- Sensitivity coefficient of surrounding temperature
- Sensitivity coefficient of supply voltage
- Cross-sensitivities
- Response time
- Difference between sample and calibration port
- Converter efficiency

Instrument readings were recorded using an external data logger.

Results obtained during the laboratory tests are summarised in section 6.

4.3 Field test

The field test was carried out with two complete and identical Serinus 40 measuring systems and lasted from 04 July 2013 to 04 October 2013. The measuring systems under test were identical to those used during laboratory testing. The serial numbers are as follows:

System 1: SN 13-0095
System 2: SN 13-0094

The following performance criteria were tested during the field test:

- Long-term drift
- Maintenance interval
- Availability
- Reproducibility standard deviation under field conditions

5. Reference measurement method

Test gases used to adjust the analyser during the test (systems under test and TÜV measuring systems)

(The mentioned test gases were used during the entire test and, where necessary, diluted with the help of a sample divider or a mass flow control station.)

Zero gas:	Synthetic air
Test gas NO:	**194 ppb in N_2**
Number of test gas cylinder:	189841
Manufacturer / date of manufacture:	SIAD / 10 September 2012
Stability guarantee / certified:	12 months
Checking of the certificate by / on:	UBA Langen / 15 January 2013
Rel. uncertainty according to certificate:	5 %
Test gas NO:	**3200 ppb in N_2**
Number of test gas cylinder:	4132569
Manufacturer / date of manufacture:	Linde / 14 May 2013
Stability guarantee / certified:	12 months
Checking of the certificate by / on:	In-house / 24 May 2013
Rel. uncertainty according to certificate:	5 %
Test gas NO:	**837 ppb in N_2**
Number of the test gas cylinder:	2519788
Manufacturer / date of manufacture:	Linde / 13 May 2013
Stability guarantee / certified:	12 months
Checking of the certificate by / on:	In-house / 24 May 2013
Rel. uncertainty according to certificate:	5 %
Test gas NO_2:	**569 ppb in synth. air**
Number of the test gas cylinder:	3903746
Manufacturer / date of manufacture:	26 March 2013 / Linde
Checking of the certificate by / on:	In-house / 24 May 2013
Rel. uncertainty according to certificate:	5 %

6. Test results according to VDI 4203 Sheet 3

6.1 4.1.1 Measured value display

The measuring system shall be fitted with a measured value display.

6.2 Equipment

No additional equipment is required.

6.3 Testing

It was checked whether the measuring system has a measured value display.

6.4 Evaluation

The measuring system has a measured value display.

6.5 Assessment

The measuring system is fitted with a measured value display.
Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 4.1.2 Easy maintenance

Necessary maintenance of the measuring system should be possible without larger effort, if possible from outside.

6.2 Equipment

No additional equipment is required.

6.3 Testing

The necessary regular maintenance tasks were performed in accordance with the instruction manual.

6.4 Evaluation

The user shall perform the following maintenance tasks:

1. Checking of the instrument status
   The status of the instrument can be checked and monitored by way of visual inspection of the display.
2. Checking and replacing the particulate filter at the sample gas inlet.
   The frequency with which particulate filters need to be replaced depends on the dust concentration in the ambient air.

6.5 Assessment

Maintenance can be carried out with usual tools in a reasonable time and from the outside.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Maintenance tasks were performed during the test and in accordance with the tasks and procedures described in the manual. Complying with these procedures, no difficulties were identified. It was thus easily possible to perform maintenance with the usual tools.

6.1 4.1.3 Functional check

If the operation or the functional check of the measuring system require particular instruments, they shall be considered as part of the measuring system and be applied in the corresponding sub-tests and included in the assessment.
Test gas units included in the measuring system shall indicate their operational readiness to the measuring system by a status signal and shall provide direct as well as remote control via the measuring system.

6.2 Equipment

Manual

6.3 Testing

The tested instrument does not have an internal device for functional checks. The operational status of the AMS is continually monitored and potential problems are displayed via an array of different error messages.

The functional check was performed with external test gases.

6.4 Evaluation

The tested instrument does not have an internal device for functional checks. The operational status of the AMS is continually monitored and potential problems are displayed via an array of different error messages.

It is possible to perform external zero point and span point checks by means of test gases.

6.5 Assessment

The instrument tested does not have an internal device for functional checks.

Does this comply with the performance criterion? not applicable

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 4.1.4 Set-up times and warm-up times

The set-up times and warm-up times shall be specified in the instruction manual.

6.2 Equipment

The testing of this performance criterion requires the additional provision of a clock.

6.3 Testing

The measuring systems were put into operation in accordance with the specifications provided by the manufacturer. The set-up times and warm-up times needed were recorded separately.

Required structural measures prior to AMS installation such as the setup of a sampling system in the analytics room were not assessed here.

6.4 Evaluation

The manual does not provide information on the set-up times. It is evident that this would depend on the specific conditions of the measurement site as well as on the voltage supply available. As the Serinus 40 measuring system is a compact analyser, the set-up time is mainly comprised of:

- Establishing the voltage supply
- Connecting necessary tubes (sampling, exhaust air)

A set-up time of approx. 0.5 h was determined for various changes in positions in the laboratory (i.e. installation/dismounting in the climate chamber) and installation in the field.

When switched on from a completely cold state the instrument requires at least 60 minutes until the reading stabilises. This time is required to bring the internal converter to operating temperature.

The measuring system has to be mounted at a place where it is protected from changes in the weather, for instance in an air conditioned measuring container.

6.5 Assessment

Set-up times and warm-up times were determined.

The measuring system may be operated at different measurement sites without undue effort. The time required for setting up the system is approx. 0.5 h and the warm-up time amounts to 1–2 h depending on the time required for stabilisation.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 4.1.5 Instrument design

The instruction manual shall include specifications of the manufacturer regarding the design of the measuring system. The main elements are:
instrument shape (e.g. bench mounting, rack mounting, free mounting)
mounting position (e.g. horizontal or vertical mounting)
safety requirements
dimensions
weight
power consumption.

6.2 Equipment

Testing was performed using a measuring instrument for the determination of the power consumption as well as weighing scales.

6.3 Testing

The set-up of the provided instruments was compared to the description in the instruction manuals. The power consumption was determined for 24 h during normal operation in the field test.

6.4 Evaluation

The measuring system has to be mounted horizontally (e.g. on a table or in a rack) and protected against weather. The temperature at the installation site may not exceed the range of 0 ° to 30 °C.

The dimensions and weight of the measuring system correspond to the specifications in the instruction manual.

According to the manufacturer, the power consumption of the measuring system is 265 W. In a 24-h test the overall power consumption was determined. The power consumption as specified by the manufacturer was not exceeded at any time during the test.

6.5 Assessment

The specifications of the manual with regard to instrument design are complete and correct.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not required in terms of this criterion.

6.1 4.1.6 Unintended adjustment

It shall be possible to secure the adjustment of the measuring system against illicit or unintended adjustment during operation.

6.2 Equipment

No additional equipment is required to test this performance criterion.

6.3 Testing

The measuring system may be operated using the display and control panel on the front side of the instrument or from an external computer connected to the RS232 or Ethernet ports.

The instrument does not have a built-in mechanism (password protection) to protect it against unintended or unauthorized re-adjustment. Changing parameters or adjusting sensors is only possible by pushing several sequences of keys.

As the system may not be set up outside, protection against unintended or unauthorised re-adjustment will have to be ensured by mounting the instrument at places where it is not possible to gain unauthorised access (e.g. locked measuring container / measuring cabinet).

6.4 Evaluation

Instrument parameters which affect measurement characteristics need to be typed in manually in complex key sequences (up-/down keys) and confirmed. It is not possible to make unintended adjustments.

In order to protect the measuring system against unauthorised adjustments it has to be mounted in a lockable environment (container/ cabinet).

6.5 Assessment

The measuring system itself is not protected against the unintended or unauthorised adjustment of instrument parameters. It has to be operated in a lockable measuring container.

Does this comply with the performance criterion? no

6.6 Detailed presentation of test results

Not required in terms of this criterion.

6.1 4.1.7 Data output

The output signals shall be provided digitally (e.g. RS232) and/or as analogue signals (e.g. 4 mA to 20 mA).

6.2 Equipment

PC and network connection

6.3 Testing

The measuring system is equipped with RS232, USB, 25-pin digital and analogue in- and outputs, TCP/IP Ethernet network connection (optional) and Bluetooth. Moreover, it has a means to output analogue signals (max. 3 analogue outputs).

6.4 Evaluation

Measured signals are output at the back of the system as follows:

Analogue:	0 – 20, 2 – 20, 4 – 20 mA or 0 – 5 V, selectable concentration range
Digital	RS232, USB, 25-pin digital in- and outputs, TCP/IP Ethernet network connection (optional) and Bluetooth

6.5 Assessment

Measured signals are provided in analogue (0-20 mA, 2-20 mA, 4-20 mA or 0-5 V) and digital form (via TCP/IP, RS232, USB; Bluetooth).

It is possible to connect additional measuring systems or peripheral devices via the respective ports (e.g. analogue inputs).

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Figure 5 shows the rear side of the instrument with its different data outputs.

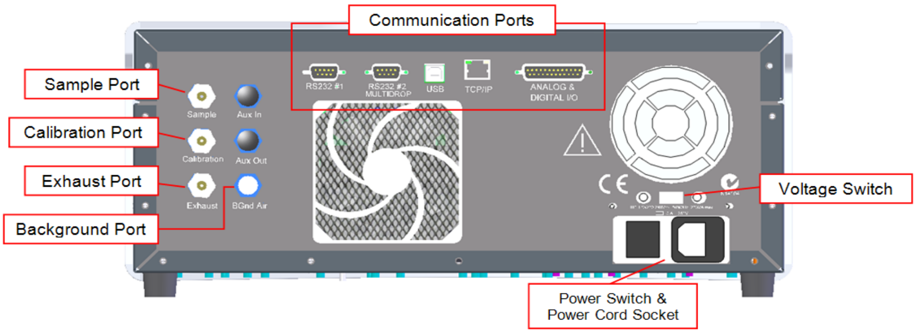


Figure 5: Rear panel of the Serinus 40

6.1 5.1 General

The manufacturer's specifications in the instruction manual shall be by no means better than the results of the performance test.

6.2 Equipment

Not required for this criterion.

6.3 Testing

The test results were compared to the specifications in the instruction manual.

6.4 Evaluation

Discrepancies between the first draft of the manual and the actual instrument design have been corrected.

6.5 Assessment

No discrepancies between the instrument design and the instruction manuals were observed.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.1 Certification range

The certification range intended for testing shall be determined.

6.2 Equipment

No additional equipment is required to test this performance criterion.

6.3 Testing

The certification range intended for testing shall be determined.

6.4 Evaluation

VDI Guideline 4202 Sheet 1 and Standard DIN EN 14211 stipulate the following minimum requirements for the certification ranges of continuous ambient air monitoring systems for nitrogen dioxide:

Table 3: Certification ranges VDI 4202 Sheet 1 and DIN EN 14211

Measured component	Lower limit CR	Upper limit CR	Limit value	Assessment period
	in µg/m³	in µg/m³	in µg/m³	
Nitrogen dioxide	0	500	200	1 h
Nitrogen monoxide	0	1200	631.3 *)	1 h

*) For NO no limit value is defined, acc. to Standard DIN EN 14211 the value 500 ±50 nmol/mol shall be used as a substitute.

6.5 Assessment

The measuring system can be assessed in the range of the relevant limit values.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.2 Measuring range

The upper limit of measurement of the measuring systems shall be greater or equal to the upper limit of the certification range.

6.2 Equipment

No additional equipment was needed to test this performance criterion.

6.3 Testing

It was determined whether the upper limit of the measuring range was greater or equal to the upper limit of the certification range.

6.4 Evaluation

In principle, the measuring system allows for measuring ranges from max. 0 – 20 ppm.

Possible measuring range:	20 ppm
Upper limit of the certification range for NO_2:	500 µg/m³

6.5 Assessment

By default the measuring range is set to 0 – 500 µg/m³ for NO_2. Other measuring ranges of max. 0 – 20 ppm are possible.

The upper limit of the measuring range is larger than the respective upper limit of the certification range.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.3 Negative output signals

Negative output signals or measured values may not be suppressed (life zero).

6.2 Equipment

No additional equipment was needed to test this performance criterion.

6.3 Testing

It was tested, in the laboratory and in the field, whether the measuring system displays negative signals.

6.4 Evaluation

The measuring system also displays negative measured values.

6.5 Assessment

The measuring system also displays negative measured values.
Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.4 Failure in the mains voltage

In case of malfunction of the measuring system or failure in the mains voltage for a period of up to 72 h, uncontrolled emission of operation and calibration gas shall be avoided. The instrument parameters shall be secured by buffering against loss caused by failure in the mains voltage. When mains voltage returns, the instrument shall automatically reach the operation mode and start the measurement according to the operating instructions.

6.2 Equipment

Not required for this criterion.

6.3 Testing

A failure in the mains voltage was simulated in order to check whether the instrument remains intact and is ready to measure when mains voltage returns.

6.4 Evaluation

The measuring system does not require any operation or calibration gases. Thus, there is no uncontrolled emission of gases in the case of failure in the mains voltage.

In the event of power failure the measuring system will switch to warm-up mode when the power supply is re-established. It will remain in this mode until an appropriate and stable temperature for operation is reached. The time required for warm-up depends on the surrounding conditions at the installation site and on the thermal condition of the instrument itself when switched on again. After warm-up the instrument automatically switches back to the same mode that was active when the power failure occurred. The warm-up phase is indicated by a number of temperature alarms.

6.5 Assessment

When mains voltage returns the measuring system goes back to a failure-free operational status and automatically resumes measuring.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.5 Operating states

The measuring system shall allow control of important operating states by telemetrically transmitted status signals.

6.2 Equipment

PC for data recording.

6.3 Testing

The measuring system has various interfaces such as RS232, USB, 25-pin digital and analogue inputs and outputs, TCP/IP Ethernet network connection (optional) and Bluetooth. By means of the “Serinus Downloader” software a connection between the analyser and an external PC can be established. This software enables telemetrical data transfer, calibration of the analyser and by choosing the menu item “Remote Screen”, the analyser display is shown on the connected PC. In this mode, all information and functions shown on the analyser display can be accessed and controlled. Moreover, the “Remote Terminal” is a useful tool to check operation and parameter values. The manufacturer also provides the “Serinus Remote” Application which enables a connection between Android devices (tablet computers or smartphones) and the analyser.

6.4 Evaluation

The measuring system allows for extensive telemetrical monitoring and control via various connectivity options. The “Serinus Downloader” software is a helpful too for data transfer and remote control of the measuring system.

6.5 Assessment

By means of various connectivity options and the “Serinus Downloader” software the measuring system can be monitored and controlled from an external PC.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.6 Switch-over

Switch-over between measurement and functional check and /or calibration shall be possible telemetrically by computer control or manual intervention.

6.2 Equipment

Not required for this criterion.

6.3 Testing

The measuring system may be monitored or controlled via the control panel of the analyser or telemetrically via remote control.

6.4 Evaluation

All control functions which do not require direct on-site intervention may be performed by operating staff on-site or telemetrically via remote control.

6.5 Assessment

In general, all necessary tasks related to functional checks may be performed directly on-site or monitored telemetrically using the remote control functions.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.7 Maintenance interval

The maintenance interval of the measuring system shall be determined during the field test and specified. The maintenance interval should be three months, if possible, but at least two weeks.

6.2 Equipment

Not required for this criterion.

6.3 Testing

In testing this performance criterion, the types of maintenance work and the corresponding maintenance intervals needed to ensure proper functioning of the measuring system were determined. Moreover, drift behaviour of zero/span point according to 7.1 8.5.4 Long term drift was taken into consideration in determining the maintenance interval.

6.4 Evaluation

During the entire field test period, no excessive drift behaviour was observed in the measuring systems. The maintenance interval is therefore determined by the necessary maintenance tasks.

During operation, maintenance tasks are generally limited to contamination and plausibility checks as well as checking for potential status signals and error warnings.

6.5 Assessment

As determined by the necessary maintenance tasks the maintenance interval is 4 weeks.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.2.8 Availability

The availability of the measuring system shall be determined during the field test and shall be at least 95 %.

6.2 Equipment

Not required for this criterion.

6.3 Testing

The start and end time of the availability test are determined by the start and end time at the field test site. To this effect any interruptions of the test, for instance due to malfunctions or maintenance work, are recorded.

6.4 Evaluation

The field test was carried out in the period from 04 July 2013 to 04 October 2013. Thus, the measuring systems were tested in the field for 93 days. Table 4 lists periods of operation, maintenance and malfunction. No malfunction was observed.

6.5 Assessment

Availability for both systems was 100 % incl. maintenance times during testing.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Table 4: Determination of availability

		System 1	System 2
Operating time	h	2242	2242
Down time	h	0	0
Maintenance time	h	15	15
Effective operating time	h	2227	2227
Effective operating time incl. maintenance	h	2242	2242
Availability	%	100	100

6.1 5.2.9 Instrument software

The version of the instrument software to be tested shall be displayed during switch-on of the measuring system. The test institute shall be informed on changes in the instrument software, which have influence on the performance of the measuring system.

6.2 Equipment

Not required for this criterion.

6.3 Testing

It was verified whether the instrument displays its current software version upon switch-on. The instrument manufacturer was advised to inform the test institute on any changes to the instrument software.

6.4 Evaluation

The current software version is displayed upon switch-on of the instrument. It may also be accessed at any time in the "configuration" menu.

The test was performed while software version 2.09.0005 was in use.

6.5 Assessment

The instrument software version is indicated in the display. Changes to the software will be communicated to the test institute.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

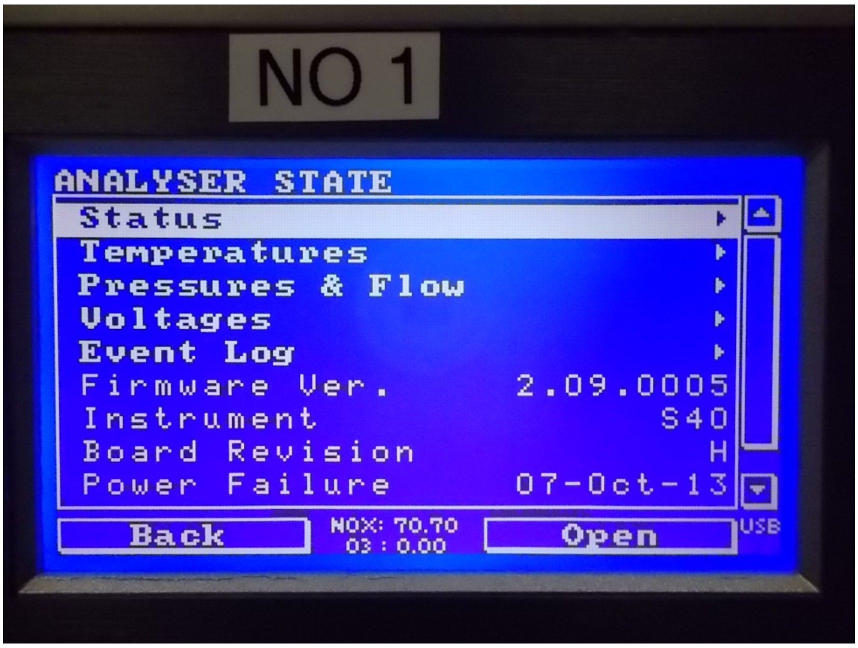


Figure 6: Display of the software version (2.09.0005) on the start screen

6.1 5.3.1 General

The tests shall be performed on the basis of the minimum requirements as stipulated in VDI 4202 Sheet 1 (September 2010).

6.2 Equipment

Not required for this criterion.

6.3 Testing

The test is performed on the basis of the minimum requirements as stipulated in VDI 4202, Sheet 1 (September 2010) and Standard DIN EN 14211 (November 2012).

6.4 Evaluation

VDI Guideline 4202 Sheet 1 and VDI Guideline 4203 Sheet 3 were revised extensively and republished in an amended version in September 2010. Minimum requirements as listed in Table 2 a/b of said guideline were used for evaluation.

6.5 Assessment

The tests were performed on the basis of the minimum requirements as stipulated in VDI 4202 Sheet 1 (September 2010) as well as Standard DIN EN 14211 (2012).

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.2 Repeatability standard deviation at zero point

The repeatability standard deviation at zero at point shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010) in the certification range according to Table 1 of VDI 4202 Sheet 1 (September 2010).

In case of deviating certification ranges, the repeatability standard deviation at zero point shall not exceed 2 % of the upper limit of this certification range.

The repeatability standard deviation at zero point shall not exceed 1.0 nnmol/mol (i.e. 1.25 µg/m³).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the repeatability standard deviation at zero point are in line with the requirements stipulated in Standard DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.5 Repeatability standard deviation.

6.4 Evaluation

Please refer to section 7.1 8.4.5 Repeatability standard deviation.

6.5 Assessment

Please refer to section 7.1 8.4.5 Repeatability standard deviation.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.3 Repeatability standard deviation at reference point

The repeatability standard deviation at reference point shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010) in the certification range according to Table 1 of VDI 4202 Sheet 1 (September 2010). The limit value or the alert threshold shall be used as reference point.

In case of deviating certification ranges, the repeatability standard deviation at reference point shall not exceed 2 % of the upper limit of this certification range. In this case a value c_t at 70 % to 80 % of the upper limit of this certification range shall be used as reference point.

The repeatability standard deviation at reference point shall not exceed 3 nmol/mol (i.e. 3.75 µg/m³).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the repeatability standard deviation at reference point are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.5 Repeatability standard deviation.

6.4 Evaluation

Please refer to section 7.1 8.4.5 Repeatability standard deviation.

6.5 Assessment

Please refer to section 7.1 8.4.5 Repeatability standard deviation.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.4 Linearity (lack of fit)

The analytical function describing the relationship between the output signal and the value of the air quality characteristic shall be linear.

Reliable linearity is given, if deviations of the group averages of measured values about the calibration function meet the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010) in the certification range according to Table 1 of VDI 4202 Sheet 1 (September 2010).

For all other certification ranges the group averages of measured values about the calibration function shall not exceed 5 % of the upper limit of the corresponding certification range.
The deviation from the linear regression shall not exceed 4 %.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the lack of fit are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.6 Lack of fit of linearity of the calibration function.

6.4 Evaluation

Please refer to section 7.1 8.4.6 Lack of fit of linearity of the calibration function.

6.5 Assessment

Please refer to section 7.1 8.4.6 Lack of fit of linearity of the calibration function.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.5 Sensitivity coefficient of sample gas pressure

The sensitivity coefficient of sample gas pressure at reference point shall not exceed the requirements of Table 2 of VDI 4202, Sheet 1 (September 2010). A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used at reference point.
The sensitivity coefficient of sample gas pressure shall not exceed 8 (nmol/mol)/kPa (i.e. (10 µg/m³)/kPa).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the sensitivity coefficient of sample gas pressure are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is referred to section 7.1 8.4.7 Sensitivity coefficient to sample gas pressure.

6.4 Evaluation

Please refer to section 7.1 8.4.7 Sensitivity coefficient to sample gas pressure.

6.5 Assessment

Please refer to section 7.1 8.4.7 Sensitivity coefficient to sample gas pressure.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.6 Sensitivity coefficient of sample gas temperature

The sensitivity coefficient of sample gas temperature at reference point shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010). A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used as reference point.
The sensitivity coefficient of sample gas temperature shall not exceed 3 (nmol/mol)/K (i.e. (3,75 µg/m³)/K).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the sensitivity coefficient of sample gas temperature are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.8 Sensitivity coefficient to sample gas temperature.

6.4 Evaluation

Please refer to section 7.1 8.4.8 Sensitivity coefficient to sample gas temperature.

6.5 Assessment

Please refer to section 7.1 8.4.8 Sensitivity coefficient to sample gas temperature.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.7 Sensitivity coefficient of surrounding temperature

The sensitivity coefficient of surrounding temperature at zero and reference point shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010). A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used as reference point.

The sensitivity coefficient of surrounding temperature shall not exceed 3 (nmol/mol)/K (i.e. (3.75 µg/m³)/K).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the sensitivity coefficient of surrounding temperature are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.9 Sensitivity coefficient to the surrounding temperature.

6.4 Evaluation

Please refer to section 7.1 8.4.9 Sensitivity coefficient to the surrounding temperature.

6.5 Assessment

Please refer to section 7.1 8.4.9 Sensitivity coefficient to the surrounding temperature.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.8 Sensitivity coefficient of supply voltage

The sensitivity coefficient of supply voltage shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010). A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used as reference point.

The sensitivity coefficient of supply voltage shall not exceed 0.3 (nmol/mol)/V (i.e. (0.38 µg/m³)/V).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the sensitivity coefficient of supply voltage are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.10 Sensitivity coefficient to electrical voltage.

6.4 Evaluation

Please refer to section 7.1 8.4.10 Sensitivity coefficient to electrical voltage

6.5 Assessment

Please refer to section 7.1 8.4.10 Sensitivity coefficient to electrical voltage.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.9 Cross-sensitivity

The change in the measured value caused by interfering components in the sample gas shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010) at zero and span point. The limit value (1 h limit value for NO = 631.3 µg/m³) shall be used as span point.
For measuring principles deviating from EN standards the absolute values of the sum of the positive and the sum of negative deviations caused by interfering components in the sample gas shall not exceed 3 % of the upper limit of the certification range at zero and reference point. A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used as reference point.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine cross-sensitivities are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.11 Interferents.

6.4 Evaluation

Please refer to section 7.1 8.4.11 Interferents.

6.5 Assessment

Please refer to section 7.1 8.4.11 Interferents.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.10 Averaging effect

For gaseous components the measuring system shall allow the formation of hourly averages.

The averaging effect shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010).
The averaging effect shall not exceed 7 % of the measured value.

6.2 Equipment

Not applicable in this instance.

6.3 Testing

Performance and evaluation of the steps taken to determine the averaging effect are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section
7.1 8.4.12 Averaging test.

6.4 Evaluation

Please refer to section
7.1 8.4.12 Averaging test.

6.5 Assessment

Please refer to section
7.1 8.4.12 Averaging test

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.11 Standard deviation from paired measurements

The standard deviation from paired measurements under field conditions shall be determined with two identical measuring systems by paired measurements in the field test. It shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010).
The standard deviation under field conditions shall not exceed 5 % of the average over a period of 3 months.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the standard deviation from paired measurements are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.5.5 Reproducibility standard deviation for NO_2 under field conditions.

6.4 Evaluation

Please refer to section 7.1 8.5.5 Reproducibility standard deviation for NO_2 under field conditions.

6.5 Assessment

Please refer to section 7.1 8.5.5 Reproducibility standard deviation for NO_2 under field conditions.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.12 Long-term drift

The long-term drift at zero point and reference point shall not exceed the requirements of Table 2 of VDI 4201 Sheet 1 (September 2010) in the field test. A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used at reference point.
The long-term drift at zero shall not exceed 5 nmol/mol (i.e. 6.3 µg/m³).
The long term drift at span point shall not exceed 5 % of the upper limit of the certification range.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the long-term drift are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.5.4 Long term drift.

6.4 Evaluation

Please refer to section 7.1 8.5.4 Long term drift.

6.5 Assessment

Please refer to section 7.1 8.5.4 Long term drift.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.13 Short-term drift

The short-term drift at zero point and reference point shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010) within 12 h (for benzene 24 h) in the laboratory test and within 24 h in the field test. A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used as reference point.
The short-term drift at zero point shall not exceed 2 nmol/mol (i.e. 2.5 µg/m³).
The short-term drift at span point shall not exceed 6 nmol/mol (i.e. 7.5 µg/m³).

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the short-term drift are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.4 Short-term drift .

6.4 Evaluation

Please refer to section 7.1 8.4.4 Short-term drift .

6.5 Assessment

Please refer to section 7.1 8.4.4 Short-term drift .

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.14 Response time

The response time (rise) of the measuring system shall not exceed 180 s.

The response time (fall) of the measuring system shall not exceed 180 s.

The difference between the response time (rise) and response time (fall) of the measuring system shall not exceed 10 % of response time (rise) or 10 s, whatever value is larger.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the response time are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.3 Response time.

6.4 Evaluation

Please refer to section 7.1 8.4.3 Response time.

6.5 Assessment

Please refer to section 7.1 8.4.3 Response time.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.15 Difference between sample and calibration port

The difference between the measured values obtained by feeding gas at the sample and calibration port shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010). A value c_t at 70 % to 80 % of the upper limit of the certification range shall be used as reference point.
The difference between sample and calibration port shall not exceed 1 %.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the difference between sample and calibration port are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.13 Difference sample/calibration port.

6.4 Evaluation

Please refer to section 7.1 8.4.13 Difference sample/calibration port.

6.5 Assessment

Please refer to section 7.1 8.4.13 Difference sample/calibration port.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.16 Converter efficiency

In case of measuring systems with a converter, the converter efficiency shall be at least 98 %.

6.2 Equipment

Not applicable here.

6.3 Testing

Performance and evaluation of the steps taken to determine the converter efficiency are in line with the requirements stipulated in DIN EN 14211 (2012). The reader is therefore referred to section 7.1 8.4.14 Converter efficiency.

6.4 Evaluation

Please refer to section 7.1 8.4.14 Converter efficiency.

6.5 Assessment

Please refer to section 7.1 8.4.14 Converter efficiency.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.17 Increase of NO_2 concentration due to residence in the measuring system

In case of NO_X measuring systems the increase of NO_2 concentration due to residence in the measuring system shall not exceed the requirements of Table 2 of VDI 4202 Sheet 1 (September 2010).

The requirements of Table 2 of VDI 4202 Sheet 1 (September 2010) apply to certification ranges according to Table 1 of VDI 4202 Sheet 1 (September 2010). For deviating certification ranges the requirements shall be proportionally converted.

6.2 Equipment

Not applicable here.

6.3 Testing

In the revised 2012 version of Standard DIN EN 14211 the test item “Increase of NO_2 concentration due to residence in the measuring system” (version 2005) has been replaced by the new test item “Residence time in the analyser”. The reader is therefore referred to section
7.1 8.4.15 Residence time in the analyser.

6.4 Evaluation

Please refer to section 7.18.4.15 Residence time in the analyser.

6.5 Assessment

Please refer to section 7.18.4.15 Residence time in the analyser.

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 5.3.18 Overall uncertainty

The expanded uncertainty of the measuring system shall be determined. The value determined shall not exceed the corresponding data quality objectives in the applicable EU Directives on air quality listed in Annex A, Table 1 of VDI 4202 Sheet 1 (September 2010).

6.2 Equipment

Not applicable here.

6.3 Testing

The determination of uncertainty was performed in accordance with DIN EN 14211 (2012) and is detailed in section 7.1 8.6 Total uncertainty in accordance with Annex E of DIN EN 14211 (2012).

6.4 Evaluation

The determination of uncertainty was performed in accordance with DIN EN 14211 (2012) and is detailed in section 7.1 8.6 Total uncertainty in accordance with Annex E of DIN EN 14211 (2012).

6.5 Assessment

The determination of uncertainty was performed in accordance with DIN EN 14211 (2012) and is detailed in section 7.1 8.6 Total uncertainty in accordance with Annex E of DIN EN 14211 (2012).

Does this comply with the performance criterion? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

7. Test results in accordance with DIN EN 14211 (2012)

7.1 8.4.3 Response time

Neither the response time (rise) nor the response time (fall) shall exceed 180 s. The difference between rise and fall response time shall not exceed 10 s.

7.2 Test procedure

The determination of the response time shall be carried out by applying to the analyser a step function in the concentration from less than 20 % to about 80 % of the maximum of the certification range of NO and vice versa.

The change from zero gas to span gas and vice versa needs to be made almost instantaneously, with the use of a suitable valve. The valve outlet shall be mounted direct to the inlet of the analyser, and both zero gas and span gas shall have the same amount of gas in excess, which is vented by the use of a tee. The gas flows of both zero gas and span gas shall be chosen in such a way that the dead time in the valve and tee can be neglected compared to the lag time of the analyser system. The step change is made by switching the valve from zero gas to span gas. This event needs to be timed and is the start (t = 0) of the (rise) lag time according to Figure 7. When the reading is stable to 98 % of the concentration applied, the span gas can be changed to zero gas again; this event is the start (t = 0) of the (fall) lag time. When the reading is stable to 2 % of the concentration applied, the whole cycle as shown in Figure 7 is complete.

The elapsed time (response time) between the start of the step change and reaching 90 % of the analyser final stable reading of the applied concentration shall be measured. The whole cycle shall be repeated four times. The average of the four response times (rise) and the average of the four response times (fall) shall be calculated.

The test shall then be repeated with NO_2 at levels from less than 20 % to about 80 % of the maximum of the certification range of NO_2 and vice versa.

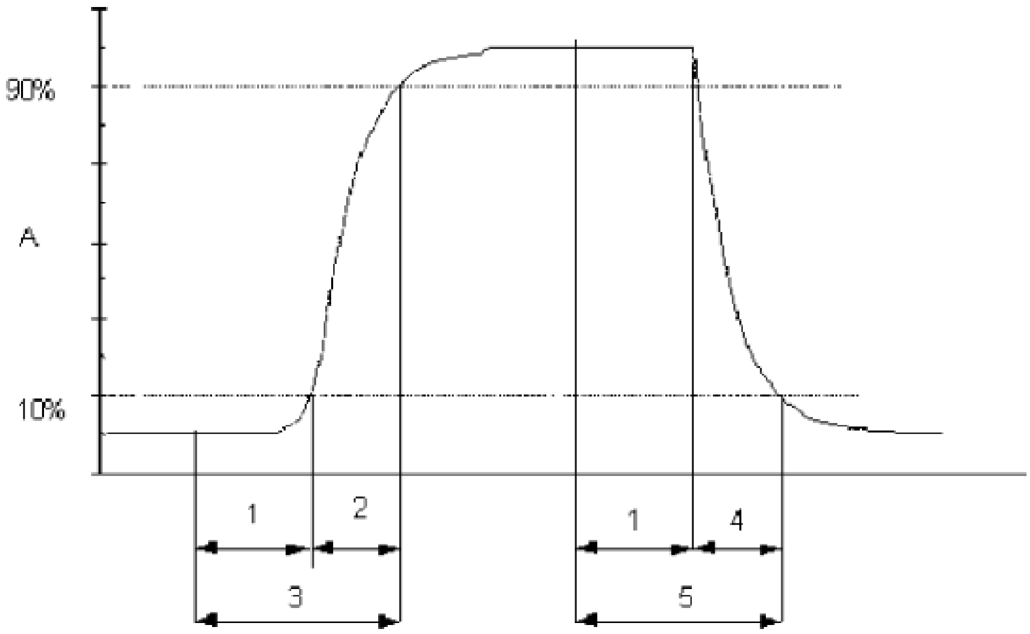
The difference in response times shall be calculated according to:

$$t_d = \bar{t}_r - \bar{t}_f$$

where

- t_d is the difference between response time (rise) and response time (fall), in s;
- t_r is the response time (rise) (average of the four response times - rise), in s;
- t_f is the response time (fall (average of the four response times - fall), in s.

t_r, t_f and t_d shall meet the performance criteria as specified above.



Key
A analyser response
1 lag time
2 rise time
3 response time (rise)
4 fall time
5 response time (fall)

Figure 7: Diagram illustrating the response time

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. Data were recorded using a Yokogawa DX2000 data logger with its averaging time set to 1 s.

7.4 Evaluation

Table 5: Response times of the two Serinus 40 measuring systems for NO

	Requirement	Device 1		Device 2	
Average rise t_r [s]	≤ 180 s	31	✓	33	✓
Average fall t_f [s]	≤ 180 s	35	✓	36	✓
Difference t_d [s]	≤ 10 s	-4	✓	-3,75	✓

For system 1 this results in a maximum t_r of 31 s, a maximum t_f of 35 s and a t_d of -4 s for NO.

For system 2 this results in a maximum t_r of 33 s, a maximum t_f of 36 s and a t_d of -3,75 s for NO.

Table 6: Response times of the two Serinus 40 measuring systems for NO_2

	Requirement	Device 1		Device 2	
Average rise t_r [s]	≤ 180 s	25	✓	24	✓
Average fall t_f [s]	≤ 180 s	33	✓	31	✓
Difference t_d [s]	≤ 10 s	-8	✓	-7,5	✓

For system 1 this results in a maximum t_r of 25 s, a maximum t_f of 33 s and a t_d of -8 s for NO_2.

For system 2 this results in a maximum t_r of 24 s, a maximum t_f of 31 s and a t_d of -7.5 s for NO_2.

7.5 Assessment

The maximum permissible response time of 180 s is exceeded at no time. The maximum response time determined for system 1 is 35 s for NO and 33 s for NO_2. The maximum response time determined for system 2 is 36 s for NO and 31 s for NO_2.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 7: Individual readings for the response times for the component NO

	80%	Device 1	Rise			Fall	
Concentration	768,00	0,0 0,00	0,9 691,20	1,0 768,00	1,0 768,00	0,1 76,80	0,0 0,00
Cycle 1	t = 0	15:20:00	15:20:45	15:21:10	15:27:00	15:27:40	15:27:58
	delta t		00:00:45			00:00:40	
	delta t [s]		45			40	
Cycle 2	t = 0	15:33:00	15:33:28	15:33:39	15:39:00	15:39:35	15:39:55
	delta t		00:00:28			00:00:35	
	delta t [s]		28			35	
Cycle 3	t = 0	15:45:00	15:45:27	15:46:05	15:51:00	15:51:33	15:51:50
	delta t		00:00:27			00:00:33	
	delta t [s]		27			33	
Cycle 4	t = 0	15:57:00	15:57:22	15:57:32	16:03:00	16:03:30	16:03:30
	delta t		00:00:22			00:00:30	
	delta t [s]		22			30	

	80%	Device 2	Rise			Fall	
Concentration	768,00	0,0 0,00	0,9 691,20	1,0 768,00	1,0 768,00	0,1 76,80	0,0 0,00
Cycle 1	t = 0	15:20:00	15:20:45	15:21:10	15:27:00	15:27:40	15:27:58
	delta t		00:00:45			00:00:40	
	delta t [s]		45			40	
Cycle 2	t = 0	15:33:00	15:33:30	15:33:56	15:39:00	15:39:35	15:39:55
	delta t		00:00:30			00:00:35	
	delta t [s]		30			35	
Cycle 3	t = 0	15:45:00	15:45:26	15:46:10	15:51:00	15:51:31	15:51:50
	delta t		00:00:26			00:00:31	
	delta t [s]		26			31	
Cycle 4	t = 0	15:57:00	15:57:30	15:57:32	16:03:00	16:03:40	16:03:46
	delta t		00:00:30			00:00:40	
	delta t [s]		30			40	

Table 8: Individual readings for the response times for the components NO_2

	80%	Device 1 Rise			Fall		
Concentration	209,21	0,0 0,00	0,9 188,28	1,0 209,21	1,0 209,21	0,1 20,92	0,0 0,00
Cycle 1	t = 0	10:38:00	10:38:22	10:38:49	10:44:00	10:44:37	10:44:52
	delta t		00:00:22			00:00:37	
	delta t [s]		22			37	
Cycle 2	t = 0	10:50:00	10:50:31	10:50:42	10:59:00	10:59:35	10:59:46
	delta t		00:00:31			00:00:35	
	delta t [s]		31			35	
Cycle 3	t = 0	11:05:00	11:05:21	11:06:20	11:13:00	11:13:31	11:15:00
	delta t		00:00:21			00:00:31	
	delta t [s]		21			31	
Cycle 4	t = 0	11:20:00	11:20:27	11:22:00	11:27:00	11:27:30	11:30:00
	delta t		00:00:27			00:00:30	
	delta t [s]		27			30	

	80%	Device 2 Rise			Fall		
Concentration	209,21	0,0 0,00	0,9 188,28	1,0 209,21	1,0 209,21	0,1 20,92	0,0 0,00
Cycle 1	t = 0	10:38:00	10:38:18	10:38:59	10:44:00	10:44:28	10:44:47
	delta t		00:00:18			00:00:28	
	delta t [s]		18			28	
Cycle 2	t = 0	10:50:00	10:50:29	10:50:55	10:59:00	10:59:32	11:00:18
	delta t		00:00:29			00:00:32	
	delta t [s]		29			32	
Cycle 3	t = 0	11:05:00	11:05:21	11:06:20	11:13:00	11:13:27	11:15:00
	delta t		00:00:21			00:00:27	
	delta t [s]		21			27	
Cycle 4	t = 0	11:20:00	11:20:27	11:27:00	11:27:00	11:27:38	11:30:00
	delta t		00:00:27			00:00:38	
	delta t [s]		27			38	

7.1 8.4.4 Short-term drift

The short-term drift at zero shall not exceed 2.0 nmol/mol/12h (i.e. 2.5 µg/m³/12h).

The short-term drift at span level shall not exceed 6.0 nmol/mol/12h (i.e. 7.5 µg/m³/12h).

7.2 Test procedure

After the required stabilisation period, the analyser shall be adjusted at zero and span level (around 70 % to 80 % of the maximum of the certification range of NO). After waiting the time equivalent to one independent reading, 20 individual measurements are recorded, first at zero and then at span concentration. From these 20 measurements, the average is calculated for zero and span level.

The analyser shall be kept running under the laboratory conditions while analysing ambient air. After a period of 12 h, zero and span gas is fed to the analyser. After waiting the time equivalent to one independent reading, 20 individual measurements are recorded, first at zero and then at span concentration. The averages for zero and span level shall be calculated.

The short-term drift at zero and span level shall be calculated as follows:

$$D_{S,Z} = (C_{Z,2} - C_{Z,1})$$

where

$D_{S,Z}$ is the 12-hour-drift at zero, in nmol/mol;

$C_{Z,1}$ is the average concentration of the measurements at zero at the beginning of the drift period, in nmol/mol;

$C_{Z,2}$ is the average concentration of the measurements at zero at the end of the drift period, in nmol/mol.

$D_{S,Z}$ shall meet the performance criterion as specified above.

$$D_{S,S} = (C_{S,2} - C_{S,1}) - D_{S,Z}$$

where

$D_{S,S}$ is the 12-hour drift at span, in nmol/mol;

$C_{S,1}$ is the average concentration of the measurements at span level at the beginning of the drift period, in nmol/mol;

$C_{S,2}$ is the average concentration of the measurements at span level at the end of the drift period, in nmol/mol;

$D_{S,S}$ shall meet the performance criterion as specified above.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. According to this standard, the test shall be performed using NO at a level of 70 % to 80 % of the certification range for NO.

7.4 Evaluation

Table 9 lists the readings obtained for the short-term drift.

Table 9: Results for the short-term drift

	Requirement	Device 1		Device 2	
Averange at zero at the beginning [nmol/mol]	-	0,00		-0,03	
Averange at zero at the end [nmol/mol]	-	0,00		0,00	
Averange at span at the beginning [nmol/mol]	-	757,48		748,17	
Averange at span at the end [nmol/mol]	-	756,37		747,71	
12-hour drift at zero $D_{s,z}$ [nmol/mol]	≤ 2,0	0,00	✓	0,03	✓
12-hour drift at span $D_{s,s}$ [nmol/mol]	≤ 6,0	-1,11	✓	-0,48	✓

7.5 Assessment

The short term drift at zero is 0.0 nmol/mol for system 1 and 0.03 nmol/mol for system 2.

The short-term drift at span point is -1.11 nmol/mol for system 1 and -0.48 nmol/mol for system 2.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Individual results of the tests are detailed in Table 10 and

.

Table 10: Start values for the short term drift

Start values		
Zero level		
	Device 1	Device 2
Time	[nmol/mol]	[nmol/mol]
17:40:00	0,0	0,0
17:40:37	0,0	0,0
17:41:14	0,0	0,0
17:41:51	0,0	0,0
17:42:28	0,0	0,0
17:43:05	0,0	-0,6
17:43:42	0,0	0,0
17:44:19	0,0	0,0
17:44:56	0,0	0,0
17:45:33	0,0	0,0
17:46:10	0,0	0,0
17:46:47	0,0	0,0
17:47:24	0,0	0,0
17:48:01	0,0	0,0
17:48:38	0,0	0,0
17:49:15	0,0	0,0
17:49:52	0,0	0,0
17:50:29	0,0	0,0
17:51:06	0,0	0,0
17:51:43	0,0	0,0
average	**0,0**	**0,0**

Start values		
Span level		
	Device 1	Device 2
Time	[nmol/mol]	[nmol/mol]
18:31:00	757,0	748,0
18:31:37	757,0	748,0
18:32:14	757,0	748,0
18:32:51	757,6	748,0
18:33:28	757,6	748,0
18:34:05	757,6	748,0
18:34:42	757,6	748,0
18:35:19	757,6	748,0
18:35:56	757,6	748,0
18:36:33	757,6	748,0
18:37:10	757,6	748,0
18:37:47	757,6	748,0
18:38:24	757,6	748,0
18:39:01	757,6	748,6
18:39:38	757,6	748,6
18:40:15	757,6	748,6
18:40:52	757,6	748,6
18:41:29	757,6	748,6
18:42:06	757,6	748,6
18:42:43	757,6	748,6
average	**757,5**	**748,2**

Table 11: End values for the short term drift

After 12h		
Zero level		
	Device 1	Device 2
Time	[nmol/mol]	[nmol/mol]
06:33:00	0,0	0,0
06:33:37	0,0	0,0
06:34:14	0,0	0,0
06:34:51	0,0	0,0
06:35:28	0,0	0,0
06:36:05	0,0	0,0
06:36:42	0,0	0,0
06:37:19	0,0	0,0
06:37:56	0,0	0,0
06:38:33	0,0	0,0
06:39:10	0,0	0,0
06:39:47	0,0	0,0
06:40:24	0,0	0,0
06:41:01	0,0	0,0
06:41:38	0,0	0,0
06:42:15	0,0	0,0
06:42:52	0,0	0,0
06:43:29	0,0	0,0
06:44:06	0,0	0,0
06:44:43	0,0	0,0
average	**0,0**	**0,0**

After 12h		
Span level		
	Device 1	Device 2
Time	[nmol/mol]	[nmol/mol]
07:34:00	755,2	747,4
07:34:37	755,2	747,4
07:35:14	755,2	747,4
07:35:51	755,8	747,4
07:36:28	755,8	747,4
07:37:05	755,8	747,4
07:37:42	755,8	747,4
07:38:19	756,4	748,0
07:38:56	756,4	748,0
07:39:33	756,4	748,0
07:40:10	756,4	748,0
07:40:47	756,4	747,4
07:41:24	757,0	748,0
07:42:01	757,0	747,4
07:42:38	757,0	748,0
07:43:15	757,0	748,0
07:43:52	757,0	748,0
07:44:29	757,0	748,0
07:45:06	757,6	748,0
07:45:43	757,6	748,6
average	**756,4**	**747,7**

7.1 8.4.5 Repeatability standard deviation

The repeatability standard deviation shall neither exceed 1.0 nmol/mol (i.e. 1.25 µg/m³) at zero nor shall it exceed 3 nmol/mol (i.e. 3.75 µg/m³) of the test gas concentration at reference point.

7.2 Test procedure

After waiting the time equivalent of one independent reading, 20 individual measurements both at zero concentration and at an NO test concentration (c_t) of (500 ± 50) nmol/mol shall be performed.

From these measurements, the repeatability standard deviation at zero concentration and at concentration c_t shall be calculated according to:

$$s_r = \sqrt{\frac{\sum \left(x_i - \bar{x}\right)^2}{n-1}}$$

where

s_r is the repeatability standard deviation, in nmol/mol;

x_i the *i*th measurement, in nmol/mol;

$\bar{x}$ is the average of the 20 measurements, in nmol/mol;

n is the number of measurements, n = 20.

The repeatability standard deviation shall be calculated separately for both series of measurements (zero gas and concentration c_t).

s_r shall meet the performance criterion as specified above, both at zero and at the NO test gas concentration c_t of (500 ± 50) nmol/mol.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. In accordance with these requirements, the test needs to be performed using the component NO. DIN EN 14211 specifies that the test shall be performed at a concentration level of 500 nmol/mol NO. According to VDI Guideline 4202 Sheet 1, the test of the repeatability standard deviation at span point shall be performed using the limit value.

7.4 Evaluation

Table 12 details the test results for the repeatability standard deviation.

Table 12: Repeatability standard deviation at zero and span point

	Requirement	Device 1		Device 2	
Repeatability standard deviation $s_{r,z}$ at zero [nmol/mol]	≤ 1,0	0,31	✓	0,19	✓
Repeatability standard deviation $s_{r,ct}$ at c_t [nmol/mol]	≤ 3,0	0,27	✓	0,19	✓
Detection limit [nmol/mol]		1,01		0,61	

7.5 Assessment

The repeatability standard deviation at zero point is 0.31 nmol/mol for system 1 and 0.19 nmol/mol for system 2. The repeatability standard deviation at span point is 0.27 nmol/mol for system 1 and 0.19 nmol/mol for system 2.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 13 lists the results of the individual measurements.

Table 13: Individual test results for the repeatability standard deviation

Zero level		
	Device 1	Device 2
Time	[nmol/mol]	[nmol/mol]
16:00:00	-1,8	0,0
16:00:36	-1,8	0,0
16:01:12	-1,8	-0,6
16:01:48	-1,8	-0,6
16:02:24	-1,8	-0,6
16:03:00	-1,8	-0,6
16:03:36	-1,8	-0,6
16:04:12	-1,8	-0,6
16:04:48	-1,8	-0,6
16:05:24	-1,8	-0,6
16:06:00	-2,4	-0,6
16:06:36	-2,4	-0,6
16:07:12	-2,4	-0,6
16:07:48	-2,4	-0,6
16:08:24	-2,4	-0,6
16:09:00	-2,4	-0,6
16:09:36	-2,4	-0,6
16:10:12	-2,4	-0,6
16:10:48	-2,4	-0,6
16:11:24	-2,4	-0,6
Average	-2,1	-0,5

C_t level		
	Device 1	Device 2
Time	[nmol/mol]	[nmol/mol]
17:06:00	520,1	509,3
17:06:36	519,5	509,3
17:07:12	519,5	509,3
17:07:48	519,5	508,7
17:08:24	519,5	508,7
17:09:00	519,5	509,3
17:09:36	519,5	509,3
17:10:12	519,5	509,3
17:10:48	519,5	509,3
17:11:24	519,5	509,3
17:12:00	519,5	509,3
17:12:36	519,5	509,3
17:13:12	519,5	509,3
17:13:48	520,1	509,3
17:14:24	519,5	509,3
17:15:00	519,5	509,3
17:15:36	520,1	509,3
17:16:12	519,5	509,3
17:16:48	520,1	509,3
17:17:24	520,1	509,3
Average	519,6	509,2

7.1 8.4.6 Lack of fit of linearity of the calibration function

The lack of fit of the calibration function shall not exceed 5 nmol/mol (i.e. 6.25 µg/m³) at zero point and 4 % of the measured value at concentrations above zero.

7.2 Test procedure

The lack of fit of linearity of the calibration function of the analyser shall be tested over the range of 0 % to 95 % of the maximum of the certification range of NO, using at least six concentrations (including the zero point). The analyser shall be adjusted at a concentration of about 90 % of the maximum of the certification range. For each change in concentration (including zero) at least five individual measurements shall be performed.

The concentrations shall be applied in the following sequence: 80 %, 40 %, 0 %, 60 %, 20 % and 95 %. After each change in concentration, at least four response times shall be taken into account before the next measurement is performed.

Calculation of the linear regression function and residuals shall be performed according to Annex A of DIN EN 14211. All the (relative) residuals from the linear regression function shall fulfil the performance criterion as stated above.

Establishing the regression line:

A regression line in the form of $Y_i = A + B * X_i$ is established through calculation of the function

$$Y_i = a + B(X_i - X_z)$$

To calculate the regression, all measuring points (including zero) are taken into account. The total number of measuring points *n* is equal to the number of concentration levels (at least six including zero) multiplied by the number of repetitions (at least five) at each concentration level.

The coefficient *a* is obtained from

$$a = \sum Y_i / n$$

where

a is the average of the Y-values
Y_i is the individual Y-value
n is the number of measuring points

The coefficient *B* is obtained from

$$B = \left(\sum Y_i (X_i - X_z)\right) / \sum (X_i - X_z)^2$$

where

X_z is the average of the X-values $\left(= \sum (X_i / n)\right)$

X_i is the individual X-value

The function $Y_i = a + B (X_i – X_z)$ is converted to $Y_i = A + B * X_i$ through the calculation of *A*

$A = a – B * X_z$

The deviations of the averages of the calibration points (including the zero point) are calculated as follows.
The average value of each calibration point (including the zero point) at one and the same concentration c is calculated according to:

$$(Y_a)_c = \sum (Y_i)_c / m$$

where

$(Y_a)_c$ is the average y-value at concentration level c
$(Y_i)_c$ is the individual y-value at concentration level c
M is the number of repetitions at one and the same concentration level c

The residual of each average (r_c) at each concentration level is calculated according to:

$$r_c = (Y_a)_c - (A + B \times c)$$

Each residual to a value relative to its own concentration level c is expressed in % as:

$$r_{c,rel} = \frac{r_c}{c} \times 100\%$$

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211.

7.4 Evaluation

The following linear regressions are obtained:

Figure 8 and Figure 9 graphically summarise the results of the determination of the group averages for NO.

Table 14: Residuals of the analytical function for NO

	Requirement	Device 1		Device 2	
Largest value of the relative residuals r_{max} [%]	≤ 4,0	0,72	✓	0,84	✓
Residual at zero r_z [nmol/mol]	≤ 5,0	0,46	✓	-0,22	✓

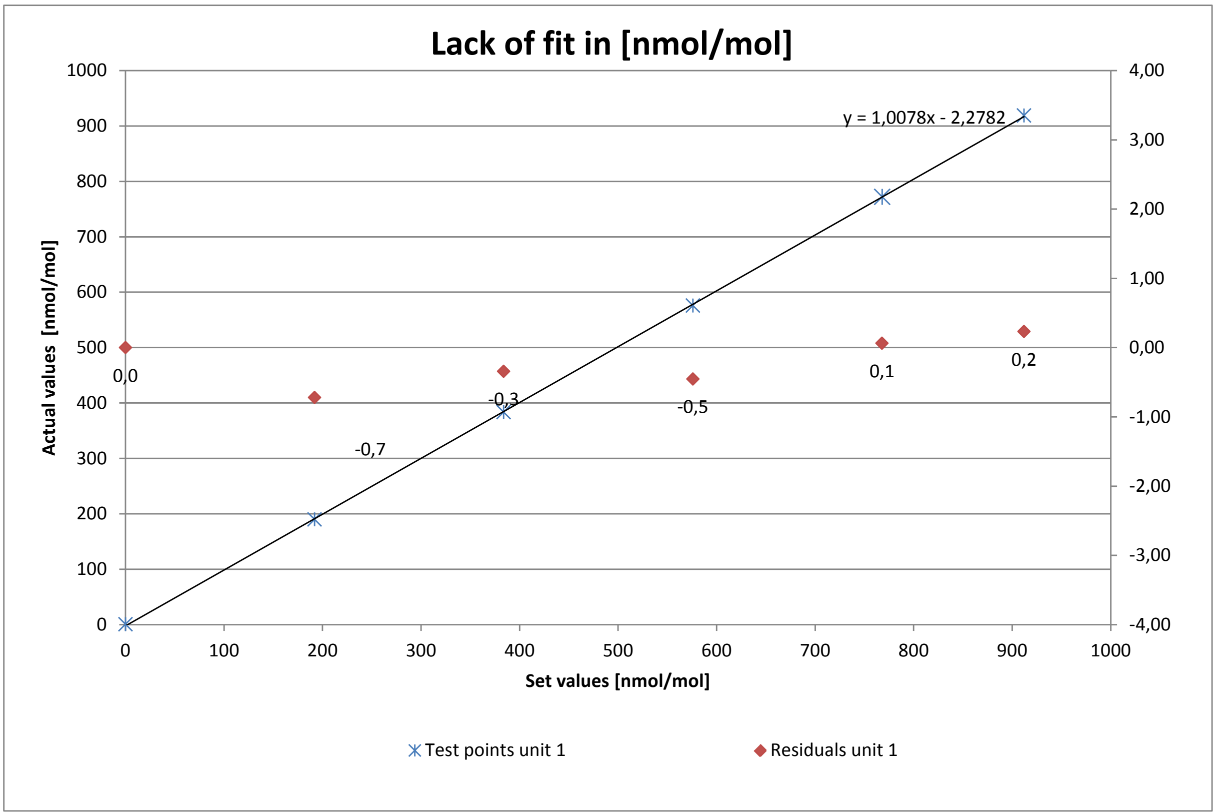


Figure 8: Function established from group averages for system 1, component NO

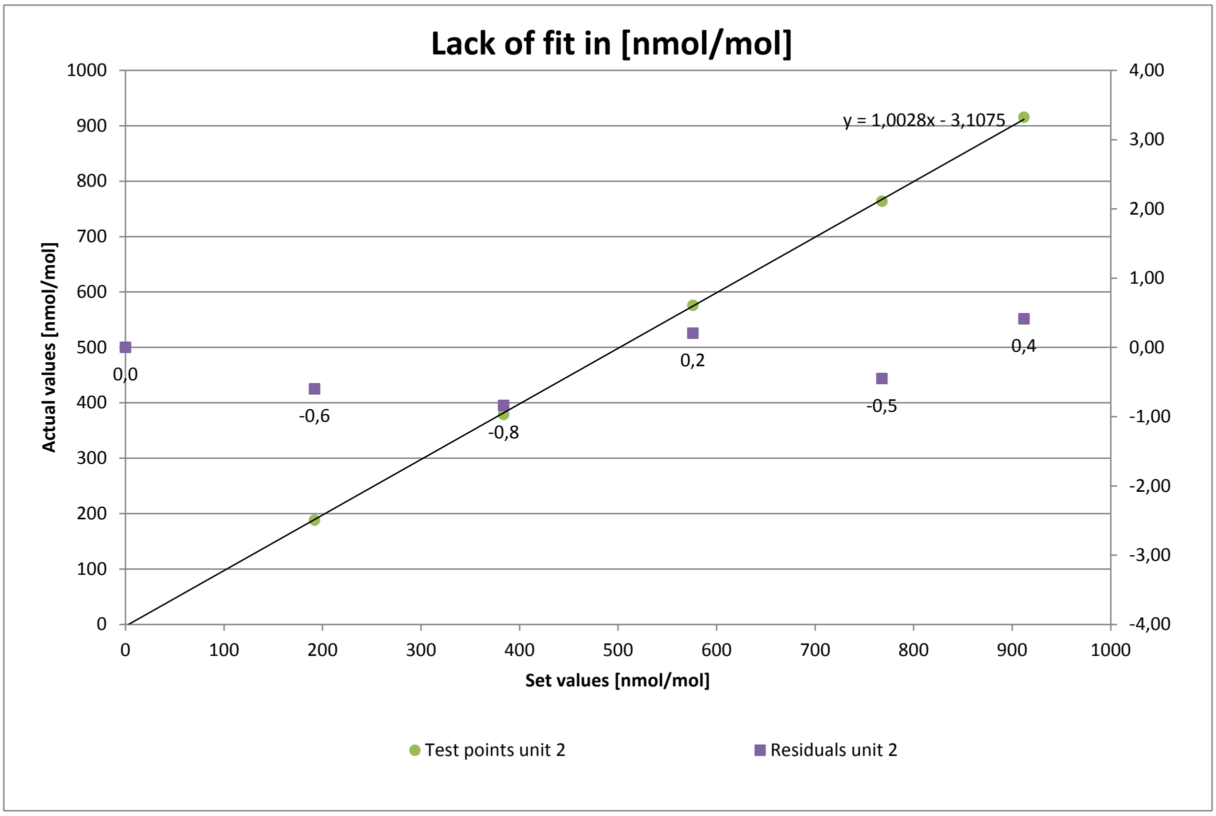


Figure 9: Function established from group averages for system 2, component NO

7.5 Assessment

For system 1, the deviation from the regression line is 0.46 nmol/mol at zero point and max. 0.72 % of the target value for concentrations greater than zero. For system 2, the deviation from the regression line is -0.22 nmol/mol at zero point and max. 0.84 % of the target value for concentrations greater than zero.

Deviations from the ideal regression line do not exceed the limit values stipulated in Standard DIN EN 14211.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Individual results of the tests are detailed in Table 15.

Table 15: Individual results of the "lack of fit" test

		Device 1 [nmol/mol]		Device 2 [nmol/mol]	
Time	Level [%]	Actual value y_i	Set value x_i	Actual value y_i	Set value x_i
15:18:00	80	774,29	768,00	760,34	768,00
15:18:36	80	773,76	768,00	757,98	768,00
15:19:12	80	772,38	768,00	765,18	768,00
15:19:48	80	770,73	768,00	766,56	768,00
15:20:24	80	769,72	768,00	767,91	768,00
15:22:00	40	382,58	384,00	377,86	384,00
15:22:36	40	384,57	384,00	377,62	384,00
15:23:12	40	381,57	384,00	378,99	384,00
15:23:48	40	382,78	384,00	379,77	384,00
15:24:24	40	385,51	384,00	379,50	384,00
15:27:00	0	0,18	0,00	-0,06	0,00
15:27:36	0	0,16	0,00	-0,22	0,00
15:28:12	0	0,42	0,00	-0,24	0,00
15:28:48	0	0,51	0,00	-0,20	0,00
15:29:24	0	1,04	0,00	-0,38	0,00
15:32:00	60	575,38	576,00	578,08	576,00
15:32:36	60	577,38	576,00	577,05	576,00
15:33:12	60	574,19	576,00	573,33	576,00
15:33:48	60	575,35	576,00	575,33	576,00
15:34:24	60	575,71	576,00	574,66	576,00
15:37:00	20	189,03	192,00	187,35	192,00
15:37:36	20	189,23	192,00	188,36	192,00
15:38:12	20	190,23	192,00	188,29	192,00
15:38:48	20	190,28	192,00	188,60	192,00
15:39:24	20	190,41	192,00	188,80	192,00
15:48:00	95	916,44	912,00	915,26	912,00
15:48:36	95	920,54	912,00	913,48	912,00
15:49:12	95	919,59	912,00	917,63	912,00
15:49:48	95	920,01	912,00	915,35	912,00
15:50:24	95	918,08	912,00	914,39	912,00

7.1 8.4.7 Sensitivity coefficient to sample gas pressure

The sensitivity coefficient to sample gas pressure shall not exceed 8.0 nmol/mol/kPa (i.e. 10 µg/m³/kPa).

7.2 Test procedure

Measurements are taken at a concentration of about 70 % to 80 % of the maximum of the certification range at an absolute pressure of about (80 ± 0.2) kPa and at an absolute pressure of about (110 ± 0.2) kPa. At each pressure after waiting the time equivalent to one independent reading, three individual measurements are recorded. From these three measurements, the averages at each pressure are calculated.

Measurements at different pressures shall be separated by at least four response times.

The sample gas pressure influence is calculated by:

$$b_{gp} = \left| \frac{(C_{P2} - C_{P1})}{(P_2 - P_1)} \right|$$

where

b_{gp} is the sample gas pressure sensitivity coefficient, in nmol/mol/kPa;

C_{P1} is the average concentration of the measurements at sampling gas pressure P_1, in nmol/mol;

C_{P2} is the average concentration of the measurements at sampling gas pressure P_2 in nmol/mol;

P_1 is the minimum sampling gas pressure P_1, in kPa;

P_2 is the maximum sampling gas pressure P_2, in kPa;

b_{gp} shall meet the performance criterion specified above.

7.3 Testing

The test was not performed in accordance with the test procedures specified in Standard DIN EN 14211.

Negative pressure was created by lowering the volume of inserted test gas by restricting the sampling line. For testing excess pressure, the analyser was connected to a test gas source. The generated test gas volume was greater than the sample gas volume sucked by the analysers. The excess gas is discharged via T-piece. To generate excess pressure, the bypass line was restricted. The test gas pressure was determined by a pressure sensor within the test gas line.

Independent measurements are taken at concentrations of about 70 % to 80 % of the maximum of the certification range and at pressures of 80 kPa and 110 kPa.

7.4 Evaluation

The following sensitivity coefficients for the influence of sample gas pressure were determined.

Table 16: Sensitivity coefficient to sample gas pressure

	Requirement	Device 1		Device 2	
Sensitivity coeff. sample gas pressure b_{gp} [nmol/mol/kPa]	≤ 8,0	1,29	✓	1,97	✓

7.5 Assessment

For system 1, the sensitivity coefficient to sample gas pressure is 1.29 nmol/mol/kPa.

For system 2, the sensitivity coefficient to sample gas pressure is 1.97 nmol/mol/kPa.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 17: Individual test results for the influence of changes in sample gas pressure

			Device 1	Device 2
Time	Pressure [kPa]	Concentration	[nmol/mol]	[nmol/mol]
12:34:00	80	720,00	678	653,4
12:35:00	80	720,00	680,4	650,4
12:36:00	80	720,00	680,4	650,4
Average C_{P1}			679,60	651,40
12:22:00	110	720,00	719,4	709,8
12:23:00	110	720,00	718,8	711,6
12:24:00	110	720,00	716,4	710,4
Average C_{P2}			718,20	710,60

7.1 8.4.8 Sensitivity coefficient to sample gas temperature

The sensitivity coefficient to sample gas temperature shall not exceed 3.0 nmol/mol/K.

7.2 Test procedure

Measurements shall be performed at sample gas temperatures of T_1 = 0 °C and T_2 = 30 °C. A concentration around 70 % to 80 % of the maximum of the certification range shall be applied. After waiting the time equivalent to one independent measurement, three individual measurements at each temperature are recorded.

The sample gas temperature, measured at the inlet of the analyser, is held constant for at least 30 min.

The influence of sample gas temperature is calculated from:

$$b_{gt} = \frac{(C_{GT,2} - C_{GT,1})}{(T_{G,2} - T_{G,1})}$$

where

b_{gt} is the sample gas temperature sensitivity coefficient, in nmol/mol/K;

$C_{GT,1}$ is the average concentration of the measurements at sample gas temperature $T_{G,1}$, in nmol/mol/K;

$C_{GT,2}$ is the average concentration of the measurements at sample gas temperature $T_{G,2}$, in nmol/mol/K;

$T_{G,1}$ is the minimum sample gas temperature $T_{G,1}$, in °C;

$T_{G,2}$ is the maximum sample gas temperature $T_{G,2}$, in °C.

b_{gt} shall meet the performance criterion specified above.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211.

For the purpose of the test, the sample gas mixture was conducted through a bundle of tubes of 20 m length, which was placed in a climate chamber. The measuring systems were set up directly in front of this chamber. The end of the bundle of tubes was connected to the measuring systems outside of the climate chamber with the opening being sealed. The test gas temperature was monitored by means of a thermocouple installed directly in front of the measuring systems. The temperature in the climate chamber was regulated so that the gas temperature at the inlets of the analysers was 0 °C. For checking the gas temperature at 30 °C, the gas was not conducted through the bundle of tubes in the climate chamber but through a tempered heating cable and then fed to the measuring systems.

7.4 Evaluation

Table 18: Sensitivity coefficient to sample gas temperature

	Requirements	Device 1		Device 2	
Sensitivity coeff. sample gas temperature b_{gt} [nmol/mol/K]	≤ 3,0	0,04	✓	0,45	✓

7.5 Assessment

For system 1, the sensitivity coefficient to sample gas temperature is 0.04 nmol/mol/K.

For system 2, the sensitivity coefficient to sample gas temperature is 0.45 nmol/mol/K.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 19: Individual values obtained from the determination of the influence of sample gas temperature for NO

			Device 1	Device 2
Time	Temp [°C]	Concentration	[nmol/mol]	[nmol/mol]
13:50:00	0	721,00	787,04	810,49
13:55:00	0	721,00	781,02	811,69
13:59:00	0	721,00	784,63	812,89
Average $C_{GT,1}$			784,23	811,69
14:38:00	30	721,00	782,23	797,26
14:42:00	30	721,00	781,63	798,46
14:48:00	30	721,00	785,23	799,06
Average $C_{GT,1}$			783,03	798,26

7.1 8.4.9 Sensitivity coefficient to the surrounding temperature

The sensitivity coefficient to the surrounding temperature shall not exceed 3.0 nmol/mol/K.

7.2 Test procedure

The sensitivity of the analyser readings to the surrounding temperature shall be determined by performing measurements at the following temperatures (within the specifications of the manufacturer):

1) at the minimum temperature T_{min} = 0 °C;
2) at the temperature within the laboratory T_l = 20 °C;
3) at the maximum temperature T_{max} = 30 °C;

For these tests, a climatic chamber is necessary.

A concentration around 70 % to 80 % of the maximum of the certification range of NO shall be applied. At each temperature setting after waiting the time equivalent to one independent measurement, three individual measurements at zero and at span shall be recorded.

The sequence of test temperatures is as follows:

T_l, T_{min}, T_l and T_l, T_{max}, T_l

At the first temperature (T_l), the analyser shall be adjusted at zero and at span level (70 % to 80 % of the maximum of the certification range).Then three individual measurements are recorded after waiting the time equivalent to one independent reading at T_l, at T_{min} and again at T_l. This measurement procedure shall be repeated at the temperature sequence of T_l, T_{max} and T_l.

In order to exclude any possible drift due to factors other than temperature, the measurements at T_l are averaged, which is taken into account in the following formula for calculation of the sensitivity coefficient for temperature dependence:

$$b_{st} = \left| \frac{x_T - \frac{x_1 + x_2}{2}}{T_S - T_{S,0}} \right|$$

where

b_{st} is the surrounding temperature sensitivity coefficient at zero or span and at T_{min} or T_{max} in nmol/mol/K;

x_T is the average of the measurements at T_{min} or $T_{max,}$ in nmol/mol;

x_1 is the first average of the measurements at $T_{1,}$ in nmol/mol;

x_2 is the second average of the measurements at $T_{1,}$ in nmol/mol;

T_S is the extreme surrounding temperature at which the test is performed in the laboratory, in °C

$T_{S,0}$ is the average of the surrounding temperatures at set point, in °C

For reporting the surrounding temperature dependence the higher value is taken of the two calculations of the temperature dependence at T_{min} or $T_{max.}$

b_{st} shall meet the performance criterion specified above.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211.

7.4 Evaluation

The following sensitivity coefficients to the surrounding temperature resulted from the tests:

Table 20: Sensitivity coefficient to the surrounding temperature at zero point and at span point, systems 1 and 2

	Requirement	Device 1		Device 2	
Sensitivity coefficient at 0 °C for zero level [nmol/mol/K]	≤ 3,0	0,295	✓	0,185	✓
Sensitivity coefficient at 30 °C for zero level [nmol/mol/K]	≤ 3,0	0,260	✓	0,050	✓
Sensitivity coefficient at 0 °C for span level [nmol/mol/K]	≤ 3,0	0,620	✓	0,240	✓
Sensitivity coefficient at 30 °C for span level [nmol/mol/K]	≤ 3,0	0,090	✓	0,070	✓

As illustrated in

Table 20, the sensitivity coefficient to the surrounding temperature at zero point and at span point complies with the performance criteria.

7.5 Assessment

The sensitivity coefficient to the surrounding temperature does not exceed the performance criteria of max. 3.0 nmol/mol/K. For both systems, the highest value b_{st} is used for the purpose of evaluating uncertainty. For system 1 it is 0.62 nmol/mol/K and for system 2 it is 0.24 nmol/mol/K.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Individual results of the tests are detailed in Table 21.

Table 21: Individual results of the test of the sensitivity to the surrounding temperature for NO

	Zero level				Span level			
			Device 1	Device 2			Device 1	Device 2
Date	Time	Temp [°C]	[nmol/mol]	[nmol/mol]	Time	Temp [°C]	[nmol/mol]	[nmol/mol]
12.06.2013	08:21:00	20	-0,6	-1,8	08:35:00	20	724,2	720,0
12.06.2013	08:23:00	20	-0,6	-1,8	08:38:00	20	726,0	720,0
12.06.2013	08:26:00	20	-1,2	-1,8	08:41:00	20	728,4	720,0
Average ($X_{1(TS1)}$)			-0,8	-1,8			726,2	720,0
12.06.2013	15:41:00	0	-7,8	-5,4	16:00:00	0	712,8	718,8
12.06.2013	15:45:00	0	-7,8	-5,4	16:14:00	0	718,2	720,0
12.06.2013	15:50:00	0	-7,8	-5,4	16:17:00	0	718,2	720,0
Average($X_{Ts,1}$)		0	-7,8	-5,4			716,4	719,6
13.06.2013	07:28:00	20	-3,0	-1,8	07:47:00	20	731,4	728,4
13.06.2013	07:31:00	20	-3,0	-1,8	07:51:00	20	730,8	729,0
13.06.2013	07:34:00	20	-3,0	-1,2	07:55:00	20	732,0	729,0
Average ($X_{2(TS1)}$) = ($X_{1(TS2)}$)			-3,0	-1,6			731,4	728,8
13.06.2013	16:20:00	30	-0,6	-1,2	16:35:00	30	734,4	732,6
13.06.2013	16:23:00	30	-0,6	-1,2	16:39:00	30	732,6	732,6
13.06.2013	16:26:00	30	0,0	-1,2	16:43:00	30	735,0	732,6
Average($X_{Ts,2}$)			-0,4	-1,2			734,0	732,6
14.06.2013	07:38:00	20	-3,0	-1,8	08:01:00	20	737,4	735,0
14.06.2013	07:41:00	20	-3,0	-1,8	08:08:00	20	738,6	735,0
14.06.2013	07:44:00	20	-3,0	-1,8	08:11:00	20	739,2	735,0
Average ($X_{2(TS2)}$)			-3,0	-1,8			738,4	735,0

7.1 8.4.10 Sensitivity coefficient to electrical voltage

The sensitivity coefficient to electrical voltage shall not exceed 0.30 nmol/mol/V (i.e. 0.38 µg/m³/V).

7.2 Test procedure

The sensitivity coefficient of electrical voltage shall be determined at both ends of the voltage range specified by the manufacturer at zero concentration and at a concentration around 70 % to 80 % of the maximum of the certification range. After waiting the time equivalent to one independent measurement, three individual measurements at each voltage and concentration level shall be recorded.

The voltage dependence in accordance with Standard DIN EN 14211 is calculated from:

$$b_v = \left| \frac{(C_{V2} - C_{V1})}{(V_2 - V_1)} \right|$$

where

b_v is the voltage sensitivity coefficient, in nmol/mol/V;

C_{V1} is the average concentration reading of the measurements at voltage V_1, in nmol/mol;

C_{V2} is the average concentration reading of the measurements at voltage V_2, in nmol/mol;

V_1 is the minimum voltage V_{min} in V specified by the manufacturer;

V_2 is the maximum voltage V_{max} in V specified by the manufacturer.

For reporting the dependence on voltage, the higher value of the result at zero and span level shall be taken.

b_v shall meet the performance criterion specified above.

7.3 Testing

For the purpose of testing the voltage sensitivity coefficient, a transformer was interposed between the analyser and the voltage supply. Sample gas was fed at various voltages at zero and span point.

7.4 Evaluation

The following sensitivity coefficients to electrical voltage resulted from the tests:

Table 22: Sensitivity coefficient to electrical voltage at zero point and at span point

	Requirement	Device 1		Device 2	
Sensitivity coeff. of voltage b_v at zero level [nmol/mol/V]	≤ 0,3	0,009	✓	0,000	✓
Sensitivity coeff. of voltage b_v at span level [nmol/mol/V]	≤ 0,3	0,045	✓	0,006	✓

7.5 Assessment

The sensitivity coefficient of electrical voltage b_v does not exceed the performance criteria of max. 0.30 nmol/mol/V stipulated in Standard DIN EN 14211 at any point. For both systems, the highest value b_v is used for the purpose of evaluating uncertainty. For system 1 it is 0.045 nmol/mol/V and for system 2 it is 0.006 nmol/mol/V.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 23: Individual results for the tests of the sensitivity coefficient to electrical voltage

Time	Voltage [V]	Concentration	Device 1 [nmol/mol]	Device 2 [nmol/mol]
09:08:00	198	0	2,4	1,2
09:09:00	198	0	2,4	1,2
09:10:00	198	0	2,4	1,2
Average C_{V1} at Zero			2,40	1,20
09:15:00	264	0	1,8	1,2
09:16:00	264	0	1,8	1,2
09:17:00	264	0	1,8	1,2
Average C_{V2} at Zero			1,80	1,20
09:30:00	198	720,00	731,4	726,6
09:31:00	198	720,00	730,8	726,6
09:32:00	198	720,00	729	727,2
Average C_{V1} at Span			730,40	726,80
09:37:00	264	720,00	727,2	727,8
09:38:00	264	720,00	727,2	727,2
09:39:00	264	720,00	727,8	726,6
Average C_{V2} at Span			727,40	727,20

7.1 8.4.11 Interferents

Interferents at zero and at an NO concentration c_t (500 ±50 nmol/mol). The highest permissible response to the interfering components H_2O, CO_2 and NH_3 shall not exceed 5.0 nmol/mol (i.e. 6.25 µg/m³) respectively.

7.2 Test procedure

The analyser response to certain interferents, which are to be expected to be present in ambient air, shall be tested. The interferents can give a positive or negative response. The test shall be performed at zero and at an NO test concentration (c_t) of (500 ± 50) nmol/mol.

The concentration of the mixtures of the test gases with the interferent shall have an expanded uncertainty of ≤ 5 % and shall be traceable to nationally accepted standards. The interferents to be tested and their respective concentrations are given in Table 24. The influence of each interferent shall be determined separately. A correction on the concentration of the measurand shall be made for the dilution effect due to addition of an interferent (e.g. water vapour).

After adjustment of the analyser at zero and span level, the analyser shall be fed with a mixture of zero gas and the interferent to be investigated with the concentration as given in Table 24. With this mixture, one independent measurement followed by two individual measurements shall be carried out. This procedure shall be repeated with a mixture of the measurand at concentration c_t and the interferent to be investigated. The influence quantity at zero and concentration c_t is calculated from:

$$X_{\text{int},z} = x_z$$

$$X_{\text{int},ct} = x_{ct} - c_t$$

where:

$X_{\text{int},z}$ is the influence quantity of the interferent at zero, in nmol/mol;

x_z is the average of the measurements of NO at zero, in nmol/mol;

$X_{\text{int},ct}$ is the influence quantity of the interferent at concentration c_t, in nmol/mol;

x_{ct} is the average of the measurements of NO at concentration c_t, in nmol/mol;

c_t is the concentration of the gas applied at a level of the hourly limit, in nmol/mol.

The influence quantities of the interferents shall comply with the performance criteria as stated above, both at zero and at concentration c_t.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. The systems were adjusted to zero concentration and to the concentration c_t (500 ppb). Zero and test gas with various interferents were then applied. Interferents and their respective concentrations used during testing are provided in Table 24.

Table 24: Interferents according to DIN EN 14211

Interferent	Value
H_2O	19 mmol/mol
CO_2	500 µmol/mol
NH_3	200 nmol/mol

7.4 Evaluation

The following table lists the influence quantities of individual interferents.

Table 25: Influence of the interferents tested (c_t = 500±50 nmol/mol)

	Requirement	**Device 1**		**Device 2**	
Influence quantity interferent H_2O at zero [nmol/mol/V]	≤ 5.0 nmol/mol	0,09	✓	-0,30	✓
Influence quantity interferent H_2O at c_t [nmol/mol/V]	≤ 5.0 nmol/mol	-0,30	✓	-0,57	✓
Influence quantity interferent CO_2 at zero [nmol/mol/V]	≤ 5.0 nmol/mol	-0,47	✓	0,60	✓
Influence quantity interferent CO2 at c_t [nmol/mol/V]	≤ 5.0 nmol/mol	1,43	✓	0,43	✓
Influence quantity interferent NH_3 at zero [nmol/mol/V]	≤ 5.0 nmol/mol	0,00	✓	-0,24	✓
Influence quantity interferent NH3 at c_t [nmol/mol/V]	≤ 5.0 nmol/mol	0,80	✓	1,41	✓

7.5 Assessment

Cross-sensitivity at zero point is 0.09 nmol/mol for system 1 and -0.30 nmol/mol for system 2 for the component H_2O, -0.47 nmol/mol for system 1 and 0.60 nmol/mol for system 2 for the component CO_2, as well as 0.00 nmol/mol for system 1 and -0.24 nmol/mol for system 2 for the component NH_3.

Cross-sensitivity at the limit value c_t is -0.03 nmol/mol for system 1 and 0.57 nmol/mol for system 2 for the component H_2O, 1.43 nmol/mol for system 1 and 0.43 nmol/mol for system 2 for the component CO_2 as well as 0.80 nmol/mol for system 1 and 1.41 nmol/mol for system 2 for the component NH_3.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 26 provides the individual readings obtained from the test.

Table 26: Individual responses to interferents

Date and interferent	Time without interferent	Time with interferent	Device 1 [nmol/mol] Without int.	Device 1 [nmol/mol] With int.	Device 2 [nmol/mol] Without int.	Device 2 [nmol/mol] With int.
Zero + H2O (19 mmol/mol)	15:26:00	15:57:00	-0,70	-0,72	-0,50	-1,07
	15:32:00	15:59:00	-0,73	-0,69	-0,79	-1,03
	15:36:00	16:02:00	-0,88	-0,63	-0,81	-0,91
	Average x_z		**-0,77**	**-0,68**	**-0,70**	**-1,00**
Span c_t + H_2O (19 mmol/mol)	16:23:00	16:44:00	513,10	515,30	517,20	522,60
	16:27:00	16:47:00	514,50	513,70	518,20	514,80
	16:30:00	16:50:00	514,20	511,90	518,10	514,40
	Average x_{ct}		**513,93**	**513,63**	**517,83**	**517,27**
Zero + CO2 (500 µmol/mol)	10:41:36	11:15:24	3,80	3,60	1,20	1,80
	10:47:27	11:18:39	4,20	3,60	1,20	1,80
	10:52:00	11:20:36	4,20	3,60	1,20	1,80
	Average x_z		**4,07**	**3,60**	**1,20**	**1,80**
Span ct + CO2 (500 µmol/mol)	12:16:30	12:38:36	517,14	517,80	512,40	512,40
	12:20:24	12:42:30	517,20	519,12	512,32	513,00
	12:26:15	12:46:24	516,72	518,43	511,80	512,40
	Average x_{ct}		**517,02**	**518,45**	**512,17**	**512,60**
Zero + NH_3 (200 nmol/mol)	Prüfgas NO, Messen NOx		**NOx**		**NOx**	
	15:45:48	15:59:27	3,60	3,60	2,60	2,49
	15:49:03	16:03:21	3,60	3,60	2,40	2,40
	15:52:57	16:09:51	3,60	3,60	3,00	2,40
	Average x_z		**3,60**	**3,60**	**2,67**	**2,43**
Span c_t + NH_3 (200 nmol/mol)	16:29:21	16:58:36	519,60	520,80	522,60	524,40
	16:33:15	17:03:09	519,60	520,80	522,60	524,62
	16:37:09	17:09:39	520,20	520,20	522,60	523,00
	Average x_{ct}		**519,80**	**520,60**	**522,60**	**524,01**

7.1 8.4.12 Averaging test

The averaging effect shall not exceed 7 % of the instrument reading.

7.2 Test procedure

The averaging test gives a measure of the uncertainty in the averaged values caused by short-term concentration variations in the sampled air shorter than the time scale of the measurement process in the analyser. In general, the output of an analyser is a result of the determination of a reference concentration (normally zero) and the actual concentration which takes a certain time.

For the determination of the uncertainty due to the averaging, the following concentrations are applied to the analyser and readings are taken at each concentration:

- a constant concentration of NO_2 at a concentration of $c_{t,NO2}$ which is about twice the hourly limit value; and
- a stepwise varied concentration of NO between zero and 600 nmol/mol (concentration $c_{t,NO}$).

The time period (t_c) of the constant NO concentration shall be at least equal to a period necessary to obtain four independent readings (which is equal to at least sixteen response times). The time period (t_v) of the varying NO concentration shall be at least equal to a period to obtain four independent readings. The time period (t_{NO}) for the NO concentration shall be 45 s followed by a period (t_{zero}) of 45 s zero concentration. Further:

c_t is the test gas concentration, in nmol/mol;

t_v is a time period including the total number of t_{NO} and t_{zero} pairs, and contains a minimum of 3 such pairs, in s.

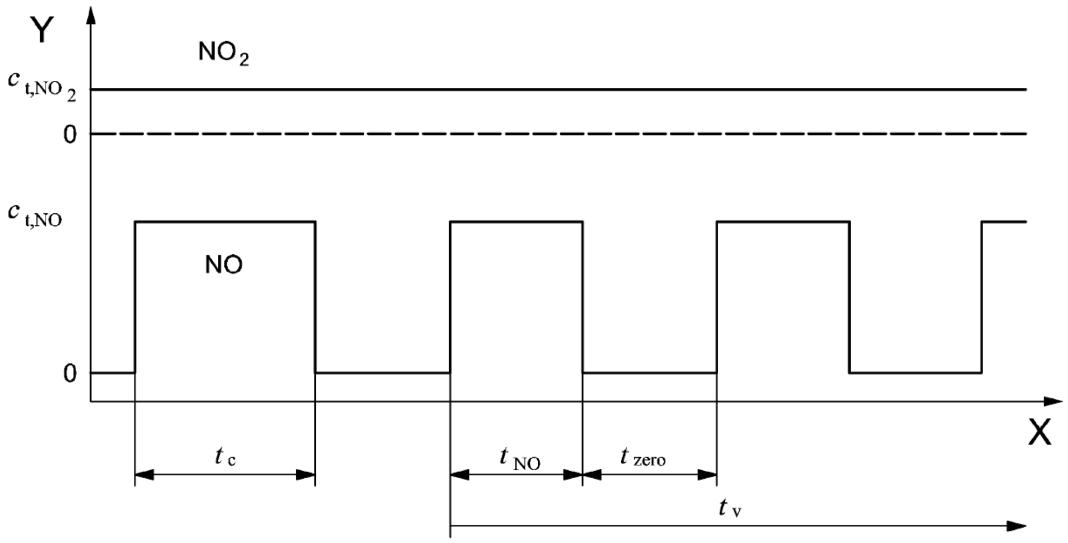
The change from t_{NO} to t_{zero} shall be within 0.5 s. The change from t_c to t_v shall be within one response time of the analyser under test.

The averaging effect (E_{av}) is calculated according to:

$$E_{av} = \frac{C_{const}^{av} - 2C_{\mathrm{var}}^{av}}{C_{const}^{av}} * 100$$

where

E_{av}	is the averaging effect (in %);
C_{const}^{av}	is the average of the at least four independent measurements during the constant concentration period (t_c), in nmol/mol;
C_{var}^{av}	is the average of the at least four independent measurements during the variable concentration period (t_v), in nmol/mol.



Key
Y concentration (nmol/mol)
X time

Figure 10: Concentration variation for the averaging test (t_{NO} = t_{zero} = 45 s)

7.3 Testing

The averaging test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. For the purpose of the test, a stepwise varied concentration of NO between zero and 600 nmol/mol as well as a constant NO_2 concentration $c_{t,NO2}$, which is about twice the hourly limit value, were applied by means of a mass flow controller station. First, the average was calculated at a constant concentration of test gas. Then, an alternating change between zero and test gas every 45 s was established using a three-way valve. For the period of alternating test gas application, the average was calculated as well.

7.4 Evaluation

The following averages were obtained during testing:

	Requirement	Device 1		Device 2	
Averaging effect E_{av} [%]	≤ 7%	-1,35	✓	-1,31	✓

This results in the following averaging effects:

System 1: -1.35 %

System 2: -1.31 %

7.5 Assessment

This is in complete compliance with the performance criteria stipulated in Standard DIN EN 14211.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 27 provides the individual results for the averaging test.

Table 27: Individual results of the averaging test

	Time	Device 1 [nmol/mol]	Device 2 [nmol/mol]
Average constant concentration $C_{av,c}$	10:50:00 till 11:06:00	615,0	613,1
Average variable concentration $C_{av,v}$	11:06:00 till 11:24:00	307,4	303,6

	Time	Device 1 [nmol/mol]	Device 2 [nmol/mol]
Average constant concentration $C_{av,c}$	11:57:00 till 12:13:00	617,1	613,0
Average variable concentration $C_{av,v}$	12:13:00 till 12:31:00	323,0	323,0

	Time	Device 1 [nmol/mol]	Device 2 [nmol/mol]
Average constant concentration $C_{av,c}$	12:41:00 till 12:57:00	615,9	612,2
Average variable concentration $C_{av,v}$	12:57:00 till 13:45:00	306,1	304,6

7.1 8.4.13 Difference sample/calibration port

The difference between sample and calibration port shall not exceed 1.0 %.

7.2 Test procedure

If the analyser has different ports for feeding sample gas and calibration gas, the difference in response of the analyser to feeding through the sample or calibration port shall be tested. The test shall be carried out by feeding the analyser with a test gas with a concentration of 70 % to 80 % of the maximum of the certification range through the sample port. The test shall consist of one independent measurement followed by two individual measurements. After a period of at least four response times, the test shall be repeated using the calibration port. The difference shall be calculated according to:

$$\Delta_{SC} = \frac{x_{sam} - x_{cal}}{c_t} \times 100$$

where

Δ_{SC}	is the difference sample/calibration port;
x_{sam}	is the average of the measured concentration using the sample port;
x_{cal}	is the average of the measured concentration using the calibration port;
c_t	is the concentration of the test gas;
Δ_{SC}	shall meet the performance criterion specified above.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. For test gas feeding the path was controlled by means of a three-way valve between sample and calibration port.

7.4 Evaluation

The following differences between sample and calibration ports were determined:

System 1: -0.26 %
System 2: 0.23 %

7.5 Assessment

This is in complete compliance with the performance criteria stipulated in Standard DIN EN 14211.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Individual results are provided in Table *28*.

Table 28: Individual results for the difference between sample and calibration port

Time	Device 1 [nmol/mol]	Device 2 [nmol/mol]
Test gas to the sample port		
18:49	719,9	738,4
18:51	719,6	738,9
18:53	719,5	739,2
Average	**719,7**	**738,8**
Test gas to the calibration port		
19:02	722,8	737,5
19:04	721,0	736,9
19:06	720,8	737,2
Average	**721,5**	**737,2**
Deviation [%]	**-0,26**	**0,23**

7.1 8.4.14 Converter efficiency

Converter efficiency shall be at least 98 %.

7.2 Test procedure

The converter efficiency is determined by measurements with known amounts of NO_2. This can be achieved by means of gas-phase titration of NO to NO_2 with ozone.

The test shall be performed at two concentration levels: at about 50 % and about 95 % of the maximum of the certification range of NO_2.

The NO_x measuring system shall be calibrated via the NO and NO_x channel, feeding an NO concentration of about 70 % to 80 % of the maximum of the certification range of NO. Both channels have to be adjusted in such a way that they display identical values. These values shall be recorded.

A known NO concentration of about 50 % of the maximum of the certification range of NO shall be applied until the output signal is stable. This stable period shall extend over at least four response times. Four individual measurements are taken at the NO and at the NO_X channel. O_3 then oxidises NO to generate NO_2. This mixture at a constant concentration of NO_X is fed to the analyser until the output signal is stable. This stable period shall extend over a minimum of four response times. The NO concentration after the gas-phase titration shall be between 10 % and 20 % of the original concentration of NO. Subsequently, four individual measurements are taken at the channels for NO and NO_X. The supply with O3 is then interrupted and only NO is fed to the analyser until the output signal is stable. This stable period shall be equivalent to at least four response times. It is then verified whether the average of the four individual measurements at the channels for NO and NO_X are identical to the original values. Potential deviations shall not exceed 1 %.

The converter efficiency is calculated from:

$$E_{conv} = \left(1 - \frac{(NO_x)_i - (NO_x)_f}{(NO)_i - (NO)_f}\right) \times 100\%$$

where

E_{conv} is the converter efficiency in %;

$(NO_x)_i$ is the average of the four individual measurements at the NO_X channel at the initial NO_X concentration in nmol/mol;

$(NO_x)_f$ is the average of the four individual measurements at the NO_X channel at the resulting NO_X concentration after applying O_3 in nmol/mol;

$(NO)_i$ is the average of the four individual measurements at the NO channel at the resulting NO concentration at the initial NO concentration in nmol/mol;

$(NO)_f$ is the average of the four individual measurements at the NO channel at the resulting NO concentration after applying O_3 in nmol/mol.

The lowest value of the two converter efficiencies shall be reported.

7.3 Testing

The test was performed in accordance with the requirements on testing as stipulated in DIN EN 14211. When the test gas was fed to the analyser, two NO_2 concentration levels in the range of 50 % to 95 % in the certification range of NO_2 were set by means of gas-phase titration.

7.4 Evaluation

The following converter efficiencies were determined during testing. The lowest of both NO_2 concentration levels is given respectively:

	Requirement	Device 1		Device 2	
Converter efficiency E_c [%]	≥ 98%	98,9	✓	98,8	✓

7.5 Assessment

This is in complete compliance with the performance criteria stipulated in Standard DIN EN 14211.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Individual results are provided in Table 29.

Table 29: Individual results of the test of converter efficiency

				Device 1		Device 2	
	Time	O_3 [nmol/mol]	NO_2 [nmol/mol]	NO [nmol/mol]	NO_x [nmol/mol]	NO [nmol/mol]	NO_x [nmol/mol]
	13:30:00	Start					
O_3=0, NO=50%	13:30:00	*0,0*	*0,0*	*486,9*	*490,9*	*489,5*	*489,7*
		0,0	*0,0*	*486,9*	*490,9*	*489,5*	*489,7*
		0,0	*0,0*	*486,9*	*490,9*	*489,5*	*489,7*
		0,0	*0,0*	*486,9*	*490,9*	*489,5*	*489,7*
Average		0,0	0,0	486,9	490,9	489,5	489,7
NO_2= 50%	13:47:00	*160,0*	*132,6*	*357,3*	*489,8*	*355,0*	*488,1*
		160,0	*132,6*	*357,3*	*489,8*	*355,0*	*488,1*
130,75		*160,0*	*132,6*	*357,3*	*489,8*	*355,0*	*488,1*
		160,0	*132,6*	*357,3*	*489,8*	*355,0*	*488,1*
Average		160,0	132,6	357,3	489,8	355,0	488,1
Converter efficiency E_c [%]				**99,2**		**98,8**	
		30 min zero gas					
O_3=0, NO=50%	15:07:00	*0,0*	*0,0*	*491,1*	*491,6*	*489,6*	*486,3*
		0,0	*0,0*	*491,1*	*491,6*	*489,6*	*486,3*
		0,0	*0,0*	*491,1*	*491,6*	*489,6*	*486,3*
		0,0	*0,0*	*491,1*	*491,6*	*489,6*	*486,3*
Average		0,0	0,0	491,1	491,6	489,6	486,3
NO_2= 95%	15:19:00	*240,0*	*241,0*	*247,9*	*488,9*	*243,6*	*484,8*
		240,0	*241,0*	*247,9*	*488,9*	*243,6*	*484,8*
248,43		*240,0*	*241,0*	*247,9*	*488,9*	*243,6*	*484,8*
		240,0	*241,0*	*247,9*	*488,9*	*243,6*	*484,8*
Average		240,0	241,0	247,9	488,9	243,6	484,8
O_3=0, NO=50%	14:32:00	*0,0*	*0,0*	*491,2*	*492,1*	*488,0*	*486,6*
Converter efficiency E_c [%]				**98,9**		**99,4**	

7.1 8.4.15 Residence time in the analyser

The residence time in the analyser shall not exceed 3.0 s.

7.2 Test procedure

The residence time inside the analyser shall be calculated on the basis of the flow and volumes of the tubing and other relevant components inside the analyser.

7.3 Testing

From sample inlet to the measuring cell, the gas volume of the Serinus 40 analyser is 23.75 ml. The nominal sample gas volume flow is 0.6 l/min. This results in a residence time inside the analyser of 2.4 s.

7.4 Evaluation

Not applicable in this instance.

7.5 Assessment

The residence time inside the analyser is 2.4 s.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Not applicable in this instance.

7.1 8.5.4 Long term drift

The long term drift at zero shall not exceed 5.0 nmol/mol (i.e. 9.36 µg/m³).
The long term drift at span level shall not exceed 5 % of the certification range (i.e. 25 µg/m³ in a measuring range of 0 to 500 µg/m³).

7.2 Test procedure

After each bi-weekly zero and span check, the drift of the analysers under test shall be calculated at zero and at span following the procedures as given underneath. If the drift compared to the initial calibration exceeds one of the performance criteria for drift at zero or span level the “period of unattended operation” equals the number of weeks until the observation of the infringement, minus two weeks. For further (uncertainty) calculations, the values for “long term drift” are the values for zero and span drift over the period of unattended operation.

At the beginning of the drift period, five individual measurements are taken immediately after the calibration at zero and span level (after waiting the time equivalent to one independent measurement).

The long term drift is calculated as follows:

$$D_{L,Z} = (C_{Z,1} - C_{Z,0})$$

where:

$D_{L,Z}$ is the drift at zero, in nmol/mol;

$C_{Z,0}$ is the average concentration of the measurements at zero at the beginning of the drift period (after the initial calibration), in nmol/mol;

$C_{Z,1}$ is the average concentration of the measurements at zero at the end of the drift period, in nmol/mol.

$D_{L,Z}$ shall meet the performance criterion as specified above.

$$D_{L,S} = \frac{(C_{S,1} - C_{S,0}) - D_{L,Z}}{C_{S,1}} \times 100$$

where

$D_{L,S}$ is the drift at span concentration c_t in %;

$C_{S,0}$ is the average concentration of the measurements at span level at the beginning of the drift period just after the initial calibration, in nmol/mol;

$C_{S,1}$ is the average concentration of the measurements at span level at the end of the drift period, in nmol/mol.

$D_{L,S}$ shall meet the performance criterion as specified above.

7.3 Testing

For the purpose of the test, test gas was applied bi-weekly. Table 30 and Table 31 list the results of this bi-weekly test gas application.

7.4 Evaluation

Table 30: Results for the long term drift at zero for the component NO

		Device 1 [nmol/mol]	Device 2 [nmol/mol]
CZ,0	04.07.2013	-0,52	-0,80
CZ,1	22.07.2013	-1,00	-0,22
DL,Z	**22.07.2013**	**-0,48**	**0,58**
CZ,1	02.08.2013	-0,70	-1,10
DL,Z	**02.08.2013**	**-0,18**	**-0,30**
CZ,1	16.08.2013	-0,83	-1,26
DL,Z	**16.08.2013**	**-0,31**	**-0,46**
CZ,1	02.09.2013	-0,70	-1,20
DL,Z	**02.09.2013**	**-0,18**	**-0,40**
CZ,1	16.09.2013	-0,29	-0,69
DL,Z	**16.09.2013**	**0,23**	**0,11**
CZ,1	30.09.2013	-0,64	-0,74
DL,Z	**30.09.2013**	**-0,12**	**0,06**
CZ,1	04.10.2013	-1,03	-1,29
DL,Z	**04.10.2013**	**-0,51**	**-0,49**

Table 31: Results for the long term drift at span point for the component NO

		Device 1 [nmol/mol]	Device 2 [nmol/mol]
CS,0	04.07.2013	721,4	721,2
CS,1	22.07.2013	728,6	731,4
DL,S	**22.07.2013**	**1,06%**	**1,33%**
CS,1	02.08.2013	738,6	734,2
DL,S	**02.08.2013**	**2,41%**	**1,84%**
CS,1	16.08.2013	727,0	723,3
DL,S	**16.08.2013**	**0,82%**	**0,35%**
CS,1	02.09.2013	730,3	706,0
DL,S	**02.09.2013**	**1,26%**	**-2,06%**
CS,1	16.09.2013	720,7	722,0
DL,S	**16.09.2013**	**-0,13%**	**0,08%**
CS,1	30.09.2013	720,1	739,7
DL,S	**30.09.2013**	**-0,16%**	**2,55%**
CS,1	04.10.2013	739,0	737,1
DL,S	**04.10.2013**	**2,51%**	**2,27%**

7.5 Assessment

The maximum long term drift at zero $D_{l,z}$ is -0.51 nmol/mol for system 1 and 0.58 nmol/mol for system 2. The maximum long term drift at span point $D_{l,s}$ is 2.51 % for system 1and 2.55 % for system 2.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

The individual results of the determination of long term drift behaviour are provided in Table 32.

Table 32: Individual results for the long term drift

Date	Time	Device 1	Device 2	Time	Device 1	Device 2
	Zero point			Span point		
	[hh:mm]	[nmol/mol]	[nmol/mol]	[hh:mm]	[nmol/mol]	[nmol/mol]
04.07.2013	07:56	-0,40	-0,80	09:11	721,6	720,9
04.07.2013	07:59	-0,40	-0,80	09:13	721,4	720,8
04.07.2013	08:01	-0,50	-0,80	09:15	721,4	721,2
04.07.2013	08:03	-0,60	-0,80	09:17	721,3	721,7
04.07.2013	08:05	-0,70	-0,80	09:19	721,3	721,6
Average		**-0,52**	**-0,80**		**721,4**	**721,2**
22.07.2013	17:20	-1,00	-0,22	17:42	728,6	731,4
02.08.2013	08:28	-0,70	-1,10	09:05	738,6	734,2
16.08.2013	08:33	-0,83	-1,26	09:32	727,0	723,3
02.09.2013	12:16	-0,70	-1,20	12:48	730,3	706,0
16.09.2013	16:03	-0,29	-0,69	16:49	720,7	722,0
30.09.2013	18:25	-0,64	-0,74	18:47	720,1	739,7
04.10.2013	13:44	-1,03	-1,29	14:14	739,0	737,1

The above listed values are averages of one independent measurement and four individual measurements.

7.1 8.5.5 Reproducibility standard deviation for NO_2 under field conditions

The reproducibility standard deviation under field conditions shall not exceed 5 % of the average over a period of 3 months.

7.2 Test procedure

The reproducibility standard deviation for NO_2 under field conditions is calculated from the measured hourly averaged data during the three-month period.

The difference $\Delta x_{f,i}$ for each (i*th*) parallel measurement is calculated from:

$$\Delta x_{f,i} = x_{f,1,i} - x_{f,2,i}$$

where

$\Delta x_{f,i}$ is the i*th* difference in a parallel measurement, in nmol/mol

$x_{f,1,i}$ is the i*th* measurement result of analyser 1, in nmol/mol

$x_{f,2,i}$ is the i*th* measurement result of analyser 2, in nmol/mol

The reproducibility standard deviation (under field conditions) is calculated according to:

$$s_{r,f} = \frac{\left(\sqrt{\frac{\sum_{i=1}^{n} \Delta x_{f,i}^2}{2*n}}\right)}{c_f} \times 100$$

where

$s_{r,f}$ is the reproducibility standard deviation for NO_2 under field conditions, in %

n is the number of parallel measurements

c_f is the average concentration of nitrogen dioxide measured during the field test, in nmol/mol

The reproducibility standard deviation for NO_2 under field conditions, $s_{r,f}$, shall meet the performance criterion as specified above.

7.3 Testing

Using the equations given above, the reproducibility standard deviation under field conditions was calculated from the data averaged hourly during the field test.

In order to demonstrate that the measuring system operates reliably at higher concentrations as well, the sample air was enriched with NO_2 from time to time.

7.4 Evaluation

Table 33: Determination of the reproducibility standard deviation on the basis of all data collected during the field test

Reproducibility standard deviation in the field test				
Number of measurements	n	=	2227	
Average of both analysers		=	76.41	nmol/mol
Standard deviation from paired measurements	sd	=	2.72	nmol/mol
Reproducibility standard deviation (%)	**Sr,f**	**=**	**3.55**	**%**

The reproducibility standard deviation under field conditions is 3.55 % of the average.

7.5 Assessment

The reproducibility standard deviation for NO_2 was 3.55 % of the average over a period of 3 months in the field. Thus, the requirements of Standard DIN EN 14211 are met.

Dies this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Figure 11 illustrates the reproducibility standard deviation under field conditions.

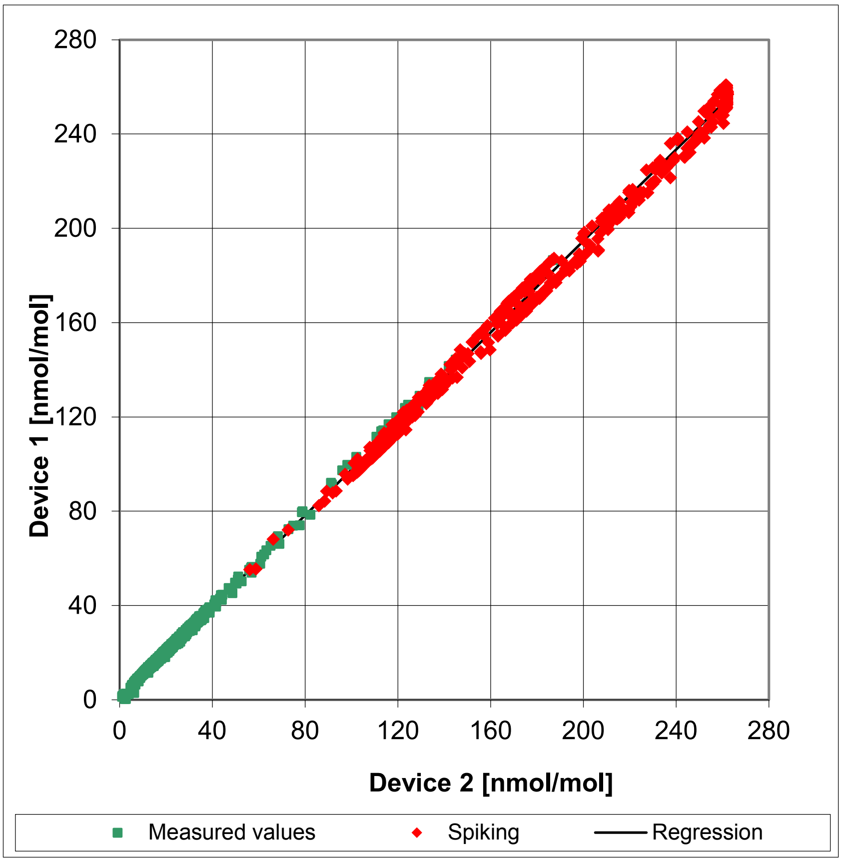


Figure 11: Illustration of the reproducibility standard deviation under field conditions

7.1 8.5.6 Period of unattended operation

The maintenance interval shall be at least 2 weeks.

7.2 Equipment

Not required for this criterion.

7.3 Testing

For this criterion, the tasks necessary to ensure proper functioning of the measuring system as well as the corresponding interval were identified. In determining the maintenance interval, the results of the drift tests at zero and span point according to 7.1 8.5.4 Long term drift were taken into consideration.

7.4 Evaluation

No excessive drift behaviour was observed during the entire period of the field test. The maintenance interval is therefore subject to the necessary maintenance tasks.

During operation, maintenance tasks may primarily be limited to contamination and plausibility checks as well as potential status signals and error warnings.

7.5 Assessment

The maintenance interval is subject to the necessary maintenance tasks and is 4 weeks.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Not applicable in this instance.

7.1 8.5.7 Period of availability of the analyser

The availability of the analyser shall be at least 90 %.

7.2 Test procedure

The correct operation of the analysers shall be checked at least every 14 days. It is recommended to perform this check every day during the first 14 days. These checks consist of plausibility checks on the measured values, as well as, when available, on status signals and other relevant parameters. Time, duration and nature of any malfunctioning shall be logged.

The total time period with useable measuring data is the period during the field test during which valid measuring data of the ambient air concentrations are obtained. In this time period, the time needed for calibrations, conditioning of sample systems and filters and maintenance shall not be included.

The availability of the analyser is calculated as:

$$A_a = \frac{t_u}{t_t} * 100$$

where

A_a is the availability of the analyser in (%)

t_u is the total time period with validated measuring data

t_t is the time period of the field test minus the time for calibration, conditioning and maintenance

t_u and t_t shall be expressed in the same units.

The availability shall meet the performance criterion as specified above.

7.3 Testing

Using the equation given above, availability was calculated on the basis of the overall time of the field test and the down times which occurred during this period.

7.4 Evaluation

The down times during the field test are listed in Table 34.

Table 34: Availability of the Serinus 40 analyser

		System 1	System 2
Time in the field	h	2242	2242
Down time	h	0	0
Maintenance	h	15	15
Total operating time	h	2227	2227
Total operating time incl. maintenance	h	2242	2242
Availability	%	100	100

Maintenance times result from the daily test gas feeding for the purpose of determining the drift behaviour and the maintenance interval as well as times required to change the internal Teflon filters in the sample gas line.

7.5 Assessment

The availability is 100 %. This complies with the requirements of Standard DIN EN 14211.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Not applicable in this instance.

7.1 8.6 Total uncertainty in accordance with Annex E of DIN EN 14211 (2012)

The type approval of the analyser consists of the following steps:

1) *The value of each individual performance characteristic tested in the laboratory shall fulfil the criterion stated in Table E.1 of DIN EN 14211.*

2) *The expanded uncertainty calculated from the standard uncertainties due to the values of the specific performance characteristics obtained in the laboratory tests shall fulfil the criterion as stated in Annex I of Directive 2008/50/EC (15 % for fixed measurements or 25 % for indicative measurements). This criterion is the maximum uncertainty of hourly values of continuous measurements at the hourly limit value. The relevant specific performance characteristics and the calculation procedure are given in Annex E of DIN EN 14211.*

3) *The value of each of the individual performance characteristics tested in the field shall fulfil the criterion stated in Table E.1 of DIN EN 14211.*

4) *The expanded uncertainty calculated from the standard uncertainties due to the values of the specific performance characteristics obtained in the laboratory and field tests shall fulfil the criterion as stated in Annex I of Directive 2008/50/EC (15 % for fixed measurements or 25 % for indicative measurements). This criterion is the maximum uncertainty of hourly values of continuous measurements at the hourly limit value. The relevant specific performance characteristics and the calculation procedure are given in Annex E of DIN EN 14211.*

7.2 Equipment

Calculation of total uncertainty in accordance with Annex E of Standard DIN EN 14211 (2012).

7.3 Testing

At the end of the tests for type approval, total uncertainty was calculated using the values obtained during testing.

7.4 Evaluation

1) The value of each individual performance characteristic tested in the laboratory fulfils the criterion stated in Table E.1 of DIN EN 14211.
2) The expanded uncertainty calculated from the standard uncertainties due to the values of the specific performance characteristics obtained in the laboratory test fulfils the criterion.
3) The value of each of the individual performance characteristics tested in the field fulfils the criterion stated in Table E.1 of DIN EN 14211.
4) The expanded uncertainty calculated from the standard uncertainties due to the values of the specific performance characteristics obtained in the laboratory and field tests fulfils the criterion.

7.5 Assessment

The total uncertainty of the measuring system complies with the performance criteria.

Does this comply with the performance criterion? yes

7.6 Detailed presentation of test results

Table 35 summarises the results for items 1 and 3.

Table 36 and Table 38 provide the results for item 2.

Table 37 and Table 39 list the results for item 4.

Table 35: Performance criteria according to DIN EN 14211

Performance characteristic	Criterion	Test result	Compliance	Page
8.4.5 Repeatability standard deviation at zero	≤ 1.0 nmol/mol	S_r System 1: 0.31 nmol/mol S_r System 2: 0.19 nmol/mol	yes	78
8.4.5 Repeatability standard deviation at the concentration c_t	≤ 3.0 nmol/mol	S_r System 1: 0.27 nmol/mol S_r System 2: 0.19 nmol/mol	yes	78
8.4.6 “lack of fit” (deviation from the linear regression)	Largest deviation from the linear regression line at concentrations above zero ≤ 4.0 % of the reading Deviation at zero ≤ 5 nmol/mol	$X_{l,z}$ System 1: NP 0.46 nmol/mol X_l System 1: RP 0.72 % $X_{l,z}$ System 2: NP -0.22 nmol/mol X_l System 2: RP 0.84 %	yes	80
8.4.7 Sensitivity coefficient to sample gas pressure	≤ 8.0 nmol/mol/kPa	b_{gp} System 1: 1.29 nmol/mol/kPa b_{gp} System 2: 1.97 nmol/mol/kPa	yes	85
8.4.8 Sensitivity coefficient to sample gas temperature	≤ 3.0 nmol/mol/K	b_{gt} System 1: 0.04 nmol/mol/K b_{gt} System 2: 0.45 nmol/mol/K	yes	87
8.4.9 Sensitivity coefficient to surrounding temperature	≤ 3.0 nmol/mol/K	b_{st} System 1: 0.62 nmol/mol/K b_{st} System 2: 0.24 nmol/mol/K	yes	89
8.4.10 Sensitivity coefficient to electric voltage	≤ 0.3 nmol/mol/V	b_v System 1: RP 0.045 nmol/mol/V b_v System 2: RP 0.006 nmol/mol/V	yes	92
8.4.11 Interferents at zero and concentration c_t	H_2O ≤ 5.0 nmol/mol CO_2 ≤ 5.0 nmol/mol NH_3 ≤ 5.0 nmol/mol	H_2O System 1: NP 0.09 nmol/mol / RP -0.3 nmol/mol System 2: NP -0.3 nmol/mol / RP -0.57 nmol/mol CO_2 System 1: NP -0.47 nmol/mol / RP 1.43 nmol/mol System 2: NP 0.6 nmol/mol / RP 0.43 nmol/mol NH_3 System 1: NP 0.0 nmol/mol / RP 0.8 nmol/mol System 2: NP -0.24 nmol/mol / RP 1.41 nmol/mol	yes	94

Performance characteristic	**Criterion**	**Test Result**	**Com-pliance**	**Page**
8.4.12 Averaging effect	≤ 7.0 % of the measured value	E_{av} System 1: -1.35 % E_{av} System 2: -1.31 %	yes	94
8.4.13 Difference sample/calibration port	≤ 1.0 %	Δ_{SC} System 1: -0.26 % Δ_{SC} System 2: 0.23 %	yes	100
8.4.3 Response time (rise)	≤ 180 s	t_r System 1: 31 s (NO) t_r System 2: 33 s (NO)	yes	69
8.4.3 Response time (fall)	≤ 180 s	t_f System 1: 35 s (NO) t_f System 2: 36 s (NO)	yes	69
8.4.3 Difference between rise and fall	≤ 10 % relative difference or 10 s, depending on which is larger	t_d System 1: -4 s t_d System 2: -3.75 s	yes	69
8.4.14 Converter efficiency	≥ 98 %	E_{conv} System 1: 98.9 % E_{conv} System 2: 98.8 %	yes	102
8.4.15 Residence in the analyser	≤ 3.0 s	System 1: 2.4 s System 2: 2.4 s	yes	103
8.5.6 Period of unattended operation	3 months or less if specified by the manufacturer, no less than 2 weeks	System 1: 4 weeks System 2: 4 weeks	yes	111
8.5.7 Availability of the analyser	> 90 %	A_a System 1: 100 % A_a System 2: 100 %	yes	113
8.5.5 Reproducibility standard deviation under field conditions	≤ 5.0 % of the average over a period of 3 months	$S_{r,f}$ System 1: 3.55 % $S_{r,f}$ System 2: 3.55 %	yes	109
8.5.4 Long-term drift at zero	≤ 5.0 nmol/mol	$C_{,z}$ System 1: -0.51 nmol/mol $C_{,z}$ System 2: 0.58 nmol/mol	yes	105
8.5.4 Long-term drift at span level	≤ 5.0 % of the maximum of the certification range	$C_{,s}$ System 1: max. 2.51 % $C_{,s}$ System 2: max. 2.55 %	yes	105
8.4.4 Short-term drift at zero	≤ 2.0 nmol/mol over a period of 12 h	$D_{s,z}$ System 1: 0.0 nmol/mol $D_{s,z}$ System 2: 0.03 nmol/mol	yes	74
8.4.4 Short-term drift at span level	≤ 6.0 nmol/mol over a period of 12 h	$D_{s,s}$ System 1: -1.11 nmol/mol $D_{s,s}$ System 2: -0.48 nmol/mol	yes	74

Table 36: Expanded uncertainty from the results of the laboratory test for system 1

Measuring device:	Ecotech Serinus 40				Serial-No.:		13-0095 (Device 1)	
Measured component:	NO_2				1h-limit value:		104,6	nmol/mol
No.	**Performance characteristic**		**Performance criterion**	**Result**	**Partial uncertainty**		**Square of partial uncertainty**	
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0,310	$u_{r,z}$	0,06	0,0035	
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0,270	$u_{r,lh}$	0,01	0,0001	
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	0,720	$u_{l,lh}$	0,43	0,1891	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	8.0 nmol/mol/kPa	1,290	u_{gp}	3,56	12,6928	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,040	u_{gt}	0,09	0,0086	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,620	u_{st}	1,55	2,3938	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	0,045	u_V	0,13	0,0171	
8a	Interferent H_20 with 21 mmol/mol	≤	10 nmol/mol (Zero)	0,090	u_{H2O}	0,01	0,0001	
		≤	10 nmol/mol (Span)	-0,300				
8b	Interferent CO_2 with 500 µmol/mol	≤	5.0 nmol/mol (Zero)	-0,470	$u_{int,pos}$			
		≤	5.0 nmol/mol (Span)	1,430	or	0,09	0,0086	
8c	Interferent NH_3 mit 200 nmol/mol	≤	5.0 nmol/mol (Zero)	0,000				
		≤	5.0 nmol/mol (Span)	0,800	$u_{int,neg}$			
9	Averaging effect	≤	7.0% of measured value	-1,350	u_{av}	-0,82	0,6647	
18	Difference sample/calibration port	≤	1.0%	-0,260	$u_{\Delta sc}$	-0,27	0,0740	
21	Converter efficiency	≥	98	98,90	u_{EC}	1,15	1,3239	
23	Uncertainty of test gas	≤	3.0%	2,000	u_{cg}	1,05	1,0941	
				Combined standard uncertainty	u_c		4,2981	nmol/mol
				Expanded uncertainty	U		8,5963	nmol/mol
				Relative expanded uncertainty	W		8,22	%
				Maximum allowed expanded uncertainty	W_{req}		15	%

Table 37: Expanded uncertainty from the results of the laboratory and field tests for system 1

Measuring device:	Ecotech Serinus 40				Serial-No.:		13-0095 (Device 1)	
Measured component:	NO_2				1h-limit value:		104,6	nmol/mol
No.	**Performance characteristic**		**Performance criterion**	**Result**	**Partial uncertainty**		**Square of partial uncertainty**	
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0,310	$u_{r,z}$	0,06	0,0035	
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0,270	$u_{r,lh}$	not considered, as √2*ur,lh = 0,01 < ur,f	-	
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	0,720	$u_{l,lh}$	0,43	0,1891	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	8.0 nmol/mol/kPa	1,290	u_{gp}	3,56	12,6928	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,040	u_{gt}	0,09	0,0086	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,620	u_{st}	1,55	2,3938	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	0,045	u_V	0,13	0,0171	
8a	Interferent H_20 with 21 mmol/mol	≤	10 nmol/mol (Zero)	0,090	u_{H2O}	0,01	0,0001	
		≤	10 nmol/mol (Span)	-0,300				
8b	Interferent CO_2 with 500 µmol/mol	≤	5.0 nmol/mol (Zero)	-0,470	$u_{int,pos}$			
		≤	5.0 nmol/mol (Span)	1,430	or	0,09	0,0086	
8c	Interferent NH_3 mit 200 nmol/mol	≤	5.0 nmol/mol (Zero)	0,000				
		≤	5.0 nmol/mol (Span)	0,800	$u_{int,neg}$			
9	Averaging effect	≤	7.0% of measured value	-1,350	u_{av}	-0,82	0,6647	
10	Reproducibility standard deviation under field conditions	≤	5.0% of average over 3 months	3,550	$u_{r,f}$	3,71	13,7886	
11	Long term drift at zero level	≤	5.0 nmol/mol	-0,510	$u_{d,l,z}$	-0,29	0,0867	
12	Long term drift at span level	≤	5.0% of max. of certification range	2,510	$u_{d,l,lh}$	1,52	2,2977	
18	Difference sample/calibration port	≤	1.0%	-0,260	$u_{\Delta sc}$	-0,27	0,0740	
21	Converter efficiency	≥	98	98,900	u_{EC}	1,15	1,3239	
23	Uncertainty of test gas	≤	3.0%	2,000	u_{cg}	1,05	1,0941	
				Combined standard uncertainty	u_c		5,8861	nmol/mol
				Expanded uncertainty	U		11,7723	nmol/mol
				Relative expanded uncertainty	W		11,25	%
				Maximum allowed expanded uncertainty	W_{req}		15	%

Table 38: Expanded uncertainty from the results of the laboratory test for system 2

Measuring device:	Ecotech Serinus 40	Serial-No.:	13-0094 (Device 2)	
Measured component:	NO_2	1h-limit value:	104,6	nmol/mol

No.	Performance characteristic		Performance criterion	Result	Partial uncertainty		Square of partial uncertainty
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0,190	$u_{r,z}$	0,04	0,0014
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0,190	$u_{r,lh}$	0,01	0,0001
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	0,840	$u_{l,lh}$	0,51	0,2573
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	8.0 nmol/mol/kPa	1,970	u_{gp}	5,37	28,8054
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,450	u_{gt}	1,02	1,0438
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,240	u_{st}	0,60	0,3647
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	0,006	u_V	0,02	0,0003
8a	Interferent H_20 with 21 mmol/mol	≤	10 nmol/mol (Zero)	0,000	u_{H2O}	-0,26	0,0700
		≤	10 nmol/mol (Span)	0,000			
8b	Interferent CO_2 with 500 µmol/mol	≤	5.0 nmol/mol (Zero)	0,600	$u_{int,pos}$	0,38	0,1434
		≤	5.0 nmol/mol (Span)	0,430	or		
8c	Interferent NH_3 mit 200 nmol/mol	≤	5.0 nmol/mol (Zero)	-0,240			
		≤	5.0 nmol/mol (Span)	1,410	$u_{int,neg}$		
9	Averaging effect	≤	7.0% of measured value	-1,310	u_{av}	-0,79	0,6259
18	Difference sample/calibration port	≤	1.0%	0,230	$u_{\Delta sc}$	0,24	0,0579
21	Converter efficiency	≥	98	98,80	u_{EC}	1,26	1,5755
23	Uncertainty of test gas	≤	3.0%	2,000	u_{cg}	1,05	1,0941

Combined standard uncertainty	u_c	5,8345	nmol/mol
Expanded uncertainty	U	11,6690	nmol/mol
Relative expanded uncertainty	W	11,16	%
Maximum allowed expanded uncertainty	W_{req}	15	%

Table 39: Expanded uncertainty from the results of the laboratory and field tests for system 2

Measuring device:	Ecotech Serinus 40	Serial-No.:	13-0094 (Device 2)	
Measured component:	NO_2	1h-limit value:	104,6	nmol/mol

No.	Performance characteristic		Performance criterion	Result	Partial uncertainty		Square of partial uncertainty
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0,190	$u_{r,z}$	0,04	0,0014
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0,190	$u_{r,lh}$	not considered, as √2*ur,lh = 0,01 < ur,f	-
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	0,840	$u_{l,lh}$	0,51	0,2573
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	8.0 nmol/mol/kPa	1,970	u_{gp}	5,37	28,8054
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,450	u_{gt}	1,02	1,0438
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	3.0 nmol/mol/K	0,240	u_{st}	0,60	0,3647
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	0,006	u_V	0,02	0,0003
8a	Interferent H_20 with 21 mmol/mol	≤	10 nmol/mol (Zero)	-0,300	u_{H2O}	-0,26	0,0700
		≤	10 nmol/mol (Span)	-0,570			
8b	Interferent CO_2 with 500 µmol/mol	≤	5.0 nmol/mol (Zero)	0,600	$u_{int,pos}$	0,38	0,1434
		≤	5.0 nmol/mol (Span)	0,430	or		
8c	Interferent NH_3 mit 200 nmol/mol	≤	5.0 nmol/mol (Zero)	-0,240			
		≤	5.0 nmol/mol (Span)	1,410	$u_{int,neg}$		
9	Averaging effect	≤	7.0% of measured value	-1,310	u_{av}	-0,79	0,6259
10	Reproducibility standard deviation under field conditions	≤	5.0% of average over 3 months	3,550	$u_{r,f}$	3,71	13,7886
11	Long term drift at zero level	≤	5.0 nmol/mol	0,580	$u_{d,l,z}$	0,33	0,1121
12	Long term drift at span level	≤	5.0% of max. of certification range	2,550	$u_{d,l,lh}$	1,54	2,3715
18	Difference sample/calibration port	≤	1.0%	0,230	$u_{\Delta sc}$	0,24	0,0579
21	Converter efficiency	≥	98	98,800	u_{EC}	1,26	1,5755
23	Uncertainty of test gas	≤	3.0%	2,000	u_{cg}	1,05	1,0941

Combined standard uncertainty	u_c	7,0932	nmol/mol
Expanded uncertainty	U	14,1864	nmol/mol
Relative expanded uncertainty	W	13,56	%
Maximum allowed expanded uncertainty	W_{req}	15	%

8. Recommendations for use

Tasks during the period of unattended operation (4 weeks)

The following checks are required on a regular basis:

- Regular visual inspections / telemetric monitoring
- Analyser status
- Error warnings
- Replacement of the Teflon filter in the sample gas inlet
- Zero and span point checks with appropriate test gases

For all intents and purposes the manufacturer’s instructions shall be considered.

Further details are provided in the manual.

Immissionsschutz/Luftreinhaltung

Guido Baum

Dipl.-Ing. Guido Baum

Dipl.-Ing. Karsten Pletscher

Cologne, 08 October 2013
936/21221977/A_EN

9. Literature

[1] VDI Guideline 4202, Sheet 1, “Performance criteria for performance tests of automated ambient air measuring systems – Point-related measurement methods for gaseous and particulate air pollutants”, September 2010

[2] VDI Guideline 4203, Sheet 3, “Testing of automated measuring systems - Test procedures for point-related ambient air measuring systems for gaseous and particulate air pollutants”, September 2010

[3] European Standard DIN EN 14211 Ambient air - Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence, November 2012

[4] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

10. Annex

Annex 1 Manual

Annex 1

Manual

ecotech
environmental monitoring solutions

Serinus 40

Oxides of Nitrogen Analyser

User Manual

Version: 2.1

www.ecotech.com

This page is intentionally blank

Table of Contents

environmental monitoring solutions

List of Figures

List of Tables

List of Equations

Manufacturer's Statement

Thank you for selecting the Ecotech Serinus 40 Oxides of Nitrogen Analyser.
The Serinus series is the next generation of Ecotech designed and manufactured gas analysers. The Serinus 40 will perform oxides of nitrogen measurements over a range of 0-20ppm with a lower detectable limit of 0.4 ppb.
This User Manual provides a complete product description including operating instructions, calibration, and maintenance requirements for the Serinus 40.
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 40 then please do not hesitate to contact Ecotech or your local Ecotech distributor.

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

Notice

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

CAUTION

Hazardous voltages exist within the analyser. The analyser lid should be closed and when the analyser is left unattended or turned on. Ensure the power cable, 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 Ecotech, 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 Ecotech as these parts meet stringent Ecotech quality assurance standards. Always disconnect the power source before removing or replacing any components.

Warranty

This product has been manufactured in an ISO 9001/ISO 14001 facility with care and attention to quality.

The product is subject to a 24-month warranty on parts and labour from date of shipment. The warranty period commences when the product is shipped from the factory. Lamps, fuses, filters, batteries and other consumable items are not covered by this warranty.

Each analyser 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 analyser to be installed and ready for use without any further testing.

Service and Repairs

Our qualified and experienced technicians are available to provide fast and friendly service between the hours of 8:30am – 5:00pm AEST Monday to Friday. You are welcome to speak to a service technician regarding any questions you have about your analyser.

Service Guidelines

In the first instance, please call or email us if you are experiencing any problems or issues with your analyser.

If you are within Australia or New Zealand please contact our service response centre via email on service@ecotech.com.au or call +61 (0)3 9730 7800

If outside of Australia and New Zealand please email our international support department at intsupport@ecotech.com or call +61 (0)3 9730 7800

If we cannot resolve the problem through technical support, please email the following information:

- Name and phone number.
- Company name.
- Shipping address.
- Quantity of items being returned.
- Model number/s or a description of each item.
- Serial number/s of each item (if applicable).
- A description of the problem.
- Original sales order or invoice number related to the equipment.

When you email us we will assign a Return Material Authorisation (RMA) number to your shipment and initiate the necessary paperwork to process your equipment within 48 hours. Please include this RMA number when you return equipment, preferably both inside and outside the shipping packaging. This will ensure you receive prompt service.

CE Mark Declaration of Conformity

This declaration applies to the Serinus 40 Oxides of Nitrogen Analyser as manufactured by Ecotech Pty. Ltd. of 1492 Ferntree Gully Rd, Knoxfield, VIC, 3180, Australia. The instrument to which this declaration relates is in conformity with the following European Union Directives:

Council Directive of 15 December 2004 on the approximation of the laws of Member States relating to electromagnetic compatibility (2004/108/EC)

The following standard was applied:

EN 61326-1:2006 Electrical Equipment for measurement, control and laboratory use – EMC Requirements – Part 1: General requirements.

Immunity Requirements EN61326-1

IEC-61000-4-2	Electrostatic discharge immunity
IEC-61000-4-3	Radiated RF immunity
IEC-61000-4-4	Electrical fast transient burst immunity
IEC-61000-4-5	Surge immunity
IEC-61000-4-6	Conducted RF Immunity
IEC-61000-4-11	Voltage dips and interruption immunity

Electromagnetic Compatibility EN61326-1

CISPR-11	Radiated RF emission measurements
CISPR-11	Mains Terminal RF emission measurements
IEC-61000-3-3	Mains Terminal voltage fluctuation measurements
IEC-61000-3-2	Power Frequency harmonic measurements

Council Directive of 12 December 2006 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits (2006/95/EC)

The following standard was applied:

EN 61010-1:2001 Safety requirements for electrical equipment, for measurement control and laboratory use – Part 1: General requirements

For protection against:

Electric shock or burn
Mechanical HAZARDS
Excessive temperature
Spread of fire from the equipment
Effects of radiation, including laser sources and sonic and ultrasonic pressure

Claims for Damaged Shipments and Shipping Discrepancies

Damaged Shipments

Inspect all instruments thoroughly on receipt. Check materials in the package(s) against the enclosed packing list. If the contents are damaged and/or the instrument fails to operate properly, notify the carrier and Ecotech immediately.
The following information is necessary to support claims:

- Original freight bill and bill of lading.
- Original invoice or photocopy of original invoice.
- Copy of packing list.

- Photographs of damaged equipment and packaging.
- Contact your freight forwarder for insurance claims.
- Retain packing material for insurance inspection.

You should keep a copy of the above for your records.
Refer to the instrument name, model number, serial number, sales order number, and your purchase order number on all claims.

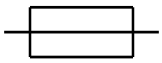
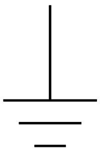
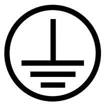
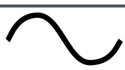
Shipping Discrepancies

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

Contact Details

Head Office
1492 Ferntree Gully Road, Knoxfield VIC Australia 3180
Phone: +61 (0)3 9730 7800 Fax: +61 (0)3 9730 7899
Email: info@ecotech.com
Service: service@ecotech.com.au
International Support: intsupport@ecotech.com
www.ecotech.com

Internationally Recognised Symbols on Ecotech Equipment

	Electrical fuse	IEC 60417-5016
	Earth (ground) terminal	IEC 60417-5017
	Protective conductor terminal	IEC 60417-5017
	Equipotentiality	IEC 60417-5021
	Alternating current	IEC 60417-5032
	Caution, hot surface	IEC 60417-5041
	Caution, risk of danger. Refer to accompanying documents	ISO 7000-0434

Caution, risk of electric shock ISO 3864-5036

Manual Revision History

Manual PN: M010028

Current revision: 2.1

Date released: 30 March 2013

Description: User Manual for the Serinus 40 Oxides of Nitrogen Analyser

This manual is the full user manual for the Serinus 40 Oxides of Nitrogen Analyser. 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 obtained by contacting Ecotech.

Edition	Date	Summary	Pages
1.0	September 2008	Initial Release	all
1.1	February 2009	General updates, specifications and menu updates	all
1.2	March 2009	New maintenance procedures Updated analyser setup Small corrections New menu items added	40, 51 12 Various 19-31
1.3	June 2009	Small correction Section 4.5 and 4.6 swapped Updated exhaust description	Various 37-38 11
1.4	November 2009	Small correction Included Serinus downloader info Included Advanced protocol	Various From 45 107
1.5	February 2010	Minor changes section 0 Updated parts list	41 87
1.6	September 2010	CE conformity added Pressurised span/zero added Updates to rack mount option Updates to Serinus downloader Update to 25 pin I/O Update to network communications	iv 102 - 98 47 49
1.7	January 2011	High level option added Updates to power specifications/battery Updates to Serial communications Updated maintenance kit	104 Various 46 87

1.8	September 2011	Analog Inputs Network Adapter Menu General overhaul of manual drawings, pictures and content	Various
2.0	July 2012	New Chassis Update menu system Add Bluetooth menu Serinus Remote Android App Rack mount procedure update Analog Output Calibration	Various
2.1	February 2013	General overhaul of manual drawings, pictures and content. Format updated.	Various

Introduction

Description

The Serinus 40 Oxides of Nitrogen Analyser uses gas phase chemiluminescence detection to perform continuous analysis of nitric oxide (NO), total oxides of nitrogen (NOx) and nitrogen dioxide (NO_2).
The Serinus 40 analyser measures to a sensitivity of 0.4 ppb with a range of 0-20 ppm. The measurement of these three gases is performed with the following main sub-components:

- NO_2 to NO converter
- Delay coil (NO_X channel)
- Ozone generator
- Reaction cell
- Photomultiplier tube (PMT)

The concentrations are automatically corrected for gas temperature and pressure changes and when using gravimetric units (eg µg/m³) is referenced to 0°C, 20°C or 25°C at 1 atmosphere. This allows the Serinus 40 to provide readings in the relevant units for your requirements.

Specifications

Measurement

Range:

0-20ppm auto ranging.
USEPA designated range: 0-0.5 ppm.
MCERTS EN certification ranges: NO (0 to 1,000 ppb) NO_2 (0 to 260 ppb).
Lower detectable limit: 0.4 ppb.

Precision/Accuracy

Precision:

0.4 ppb or 0.5% of reading, whichever is greater.

Linearity:

±1% of full scale.

Response Time:

15 seconds to 90%.

Sample Flow Rate:

0.3 SLPM (0.6 SLPM total flow for two channels).

Calibration

Zero Drift:

Temperature dependant:	0.1 ppb per °C.
24 hours:	< 0.4 ppb
7 days: < 1.0 ppb	

Span Drift:

Temperature dependant: 0.1% per °C
7 days: < 1% of reading.

Power

Operating Voltage:

99 to 132 VAC (57-63Hz) or via switch 198 to 264 VAC (47 to 53 Hz).
U.S. EPA designated range: 105 to 125 VAC, 60 Hz.

Power Consumption:

265VA max. (typical at start-up).
190VA after warm -up.

Fuse Rating:

20x5mm, T 250V, 5A (slow blow).

Operating Conditions

Ambient Temperature Range:

0 °C to 40 °C (32 °F to 104 °F).
U.S. EPA designated range: 20 °C to 30 °C.

Sample Pressure Dependence:

5% change in pressure produces less than a 1% change in reading.
Maximum altitude: 3000m above sea level.

Communications

- USB port connection on rear panel.
- Bluetooth (digital communication via Android App).
- TCP/IP Ethernet network connection (optional).
- RS232 port #1: Normal digital communication or termination panel connections.
- RS232 port #2: Multidrop port used for multiple analyser connections on a single RS232.
- USB memory stick (front panel) for data logging, event logging and parameter/configuration storage.

Protocols

- Modbus RTU/TCP, Bavarian, EC9800, Advanced

25 pin I/O Port

- Three analog outputs (menu selectable current or voltage output).
  - Current output of 0-20 mA, 2-20 mA or 4-20 mA.
  - Voltage output of 0 to 5 V, with menu selectable zero offset of 0V, 0.25V or 0.5V.
  - Range: 0 to full scale from 0-0.05 ppm to 0-20 ppm.
- 8 digital outputs, open collector 150mA each.
- 8 digital inputs, 0-5VDC, CAT I rated.

- Three analog voltage inputs (0-5VDC) CAT I rated.

Physical Dimensions

Case Dimensions:

Rack Length (front to rear):	597 mm (23.5")
Total Length (w/ latch release):	638 mm (25.1")
Chassis Width:	418 mm (16.5")
Front Panel Width:	429 mm (16.9")
Chassis Height:	163 mm/Uses 4RU (6.4")
Front Panel Height:	175 mm (6.9")

Weight: 21.9 kg

Certifications

- US EPA approved (RFNA-09-078-15)
- EN approval Sira MC 100167/02
- Chemiluminescence method EN14211
- Chemiluminescence method AS 3580.5.1-2011

Nomenclature

NO: Nitrogen oxide, or nitric oxide.
NO_2: Nitrogen dioxide.
NO_x: A generic term for mono-nitrogen oxides NO and NO_2.
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 scrubbed ambient air) to calibrate/check the lower range of the instrument.
Background Cycle: Removes unwanted signal from the measurement signal. This is accomplished by pre-reacting the sample gas with ozone outside the measurement cell. The pre-reacted gas is then fed into the cell where this signal is stored as the background signal. This background measurement is then used to correct the sample measurement by subtracting the background signal from the measurement signal. Background cycle can be described as a dynamic zero where unwanted signals generated from the photomultiplier tube (detector) due to internal offsets (dark current) or unwanted cell luminescences are removed.
Zero Drift: the change in instrument response to zero pollutant concentration over time.
Zero Air: Is purified air in which the concentration of NO is <0.5ppb and NO_2 is <0.5ppb with water vapour of less than 10% RH. Sufficient purified air can be obtained by passing dry ambient air through an activated charcoal filter, a purafil cartridge and a particulate filter.
External Span Source: Span gas that is delivered via an external accredited cylinder containing NO in balance with N_2 (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 analyser.
ID and OD: These are measurements of tubing, ID is the internal diameter of tubing, OD is the outer diameter.
Multidrop: A configuration of multiple analysers connected via the same RS232 cable.

Photomultiplier Tube: A highly sensitive device which can detect extremely low levels of light (photons) and multiply the electrical signal to a point where it can be accurately measured. These are often called PMTs for short.
Bootloader: A program that checks whether the current firmware is valid, then executes the instrument start-up. The bootloader can be entered by pressing the '+' key on the front keypad during the first ½ second after power on, and following the prompts. The bootloader then enables various low level recovery tools, including updating the main firmware from a USB key.

Background/Theory

Oxides of Nitrogen (NOx) are the product of endothermic reactions within combustion engines and cause significant environmental pollution.
The main source of NOx emissions is from hydrocarbon combustion such as automobile engines or the burning of coal for power production. These pollutants are harmful to humans and create ozone gas (O_3) and acid rain. NOx is a major component of the smog found in industrial cities and is harmful to people with respiratory diseases such as asthma.

Measurement Theory

The measurement of the Oxides of Nitrogen is performed using the gas phase chemiluminescence method.

- Sample air enters the reaction cell via two separate (alternating) paths; the NO and NO_X channels.
- NO in the first path reacts with ozone in the following reaction.

$$NO + O_3 \rightarrow NO_2^* + O_2$$

Equation 1 – Chemiluminescence reaction for NO

Note: The chemiluminescence reaction is between O_3 and NO only; not NO_2.

- The second path travels through a delay loop and the NO_2 to NO converter such that it reaches the reaction cell after the first path. At which point the NO_x measurement (the combined concentration of NO and NO_2) is taken.
- The concentration of NO_2 is then calculated by subtracting the NO measurement from the NOx measurement.

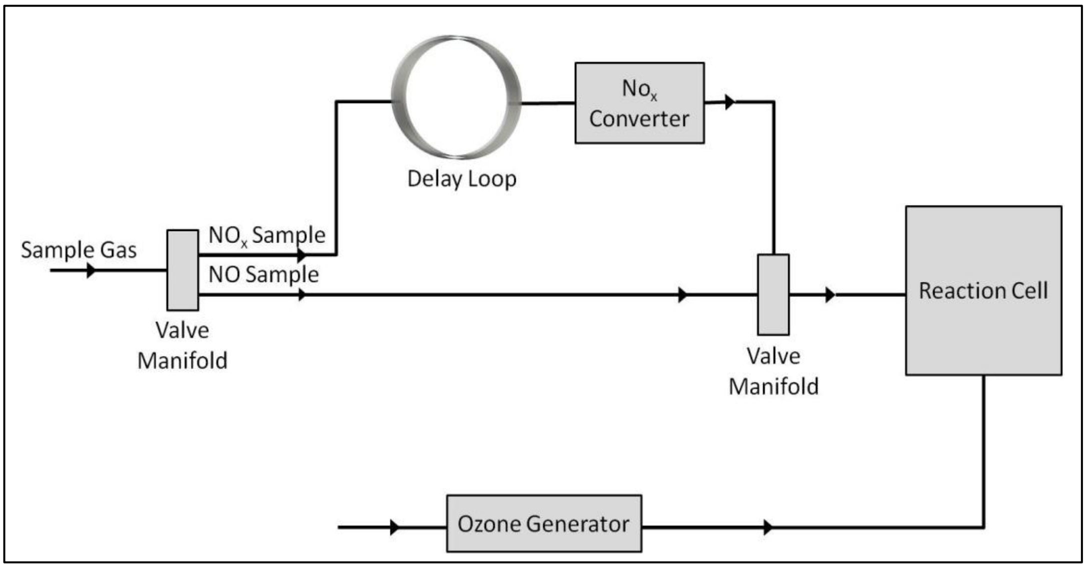


Figure 1 - Simple pneumatic diagram

- This reaction releases energy in the form of chemiluminescence radiation at 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.
- The concentration of NO_2 is calculated by subtracting the NO measurement from NO_X measurement.

$$NO_X = NO + NO_2$$

or

$$NO_2 = NO_X - NO$$

Equation 2 - NO_2 calculation

Kalman Filter Theory

The digital Kalman filter provides an ideal compromise between response time and noise reduction for the type of signal and noise present in ambient air analysers.
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 analyses the signal and uses the appropriate filtering time.

Instrument Description

The oxides of nitrogen analyser consists of five main assemblies:

- The pneumatics to transfer sample and exhaust gas (including the valve manifolds).
- The sensors for the measurement of oxides of nitrogen (reaction cell assembly) 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.

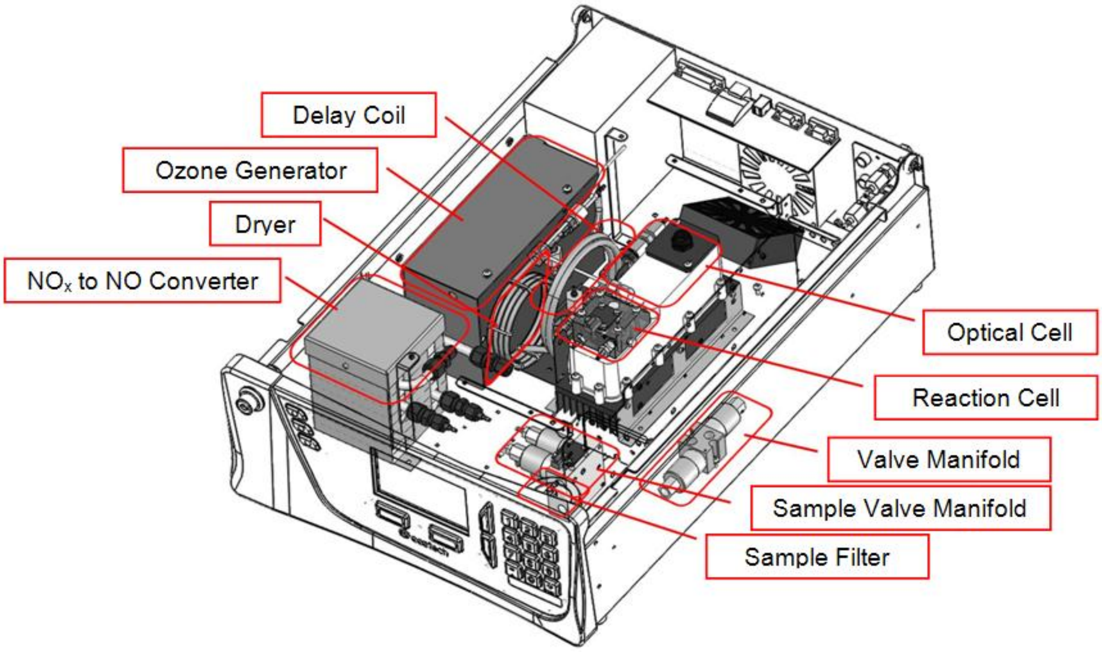


Figure 2 - Internal components diagram

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.

Delay Loop

The delay loop is a coil of sample tubing which increases the length of time sample air takes to travel to the NO2 to NO converter and the measurement chamber. This delay allows a single sample to be split into the NO channel and the NOx channel and measured sequentially without introducing a lag on the measurement of the NO_x channel. ie The sample of NO_x gas is taken at the same time as the NO, but measured after the NO, in the same cell.

Dryer

The dryer is constructed of Nafion tubing, and is designed to remove water vapour from ambient air that is used by the ozone generator. The water is absorbed and moves through the walls of the tubing, evaporating into the surrounding air. The remaining gas is unaffected. The flow rate control is performed by utilising a critical orifice.

Ozone Generator

The ozone generator is a corona discharge ozone source driven by an ignition coil. Dry air is drawn into the discharge tube via an orifice and then ionised by a high voltage electrode. This yields O_3 from the reaction 3O2 →2O3. The ionisation takes place in the confines of a glass tube with the electrode mounted on the outside. The amount of ozone generated is controlled by varying the energy to the discharge tube. The ozone flow rate is approximately 80 cc/min with an ozone concentration of 6000 - 8000 ppm.

NO_2 to NO Converter

The NO_2 to NO converter uses high temperatures (325°C) and a catalyst to convert any NO_2 in the sample to NO.

The NO_2 to NO converter assembly also houses a catalytic ozone destroyer that removes ozone from the instrument exhaust.

To obtain accurate and stable results, the converter must operate at above 96% (US EPA) or 95% (Australian standard) efficiency.

Sample Valve Manifold

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

Auxiliary Valve Manifold

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

Pressure Transducers

Two pressure transducers are used for the calculation of sample flow rate. One is located upstream to the critical orifice (manifold pressure) and the other is located in the reaction cell downstream of the critical orifice (cell pressure).

Optical Cell

Reaction Cell Assembly

The reaction cell is where ozone and NO mix to create a chemiluminescence reaction which emits radiation. A portion of this radiation is filtered to a specific wavelength (1100nm) and measured by the PMT.

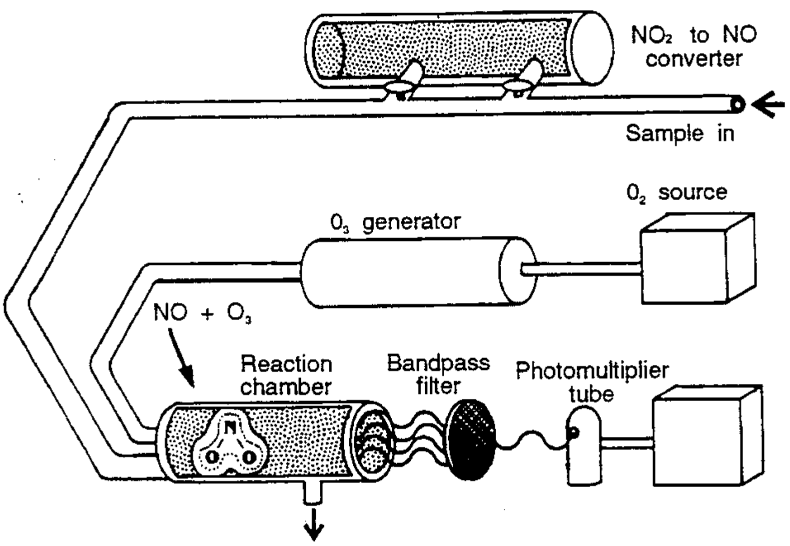


Figure 3 - Reaction cell operation

Optical Bandpass Filter

The optical bandpass filter is constructed of coloured glass that only allows the transmission of light between 600nm-1200nm.

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

The PMT cooler ensures that the PMT is operated at a constant 13 deg C. This reduces the noise of the PMT.

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.

Main Controller PCB

The main controller PCB controls all the processes within the instrument. It contains a battery backed clock, calendar and an on-board microprocessor. The main controller PCB is located on top of the other components with the analyser. The PCB pivots on hinges to allow access to the components underneath.

CAUTION

Never place objects on top of the main controller PCB as it may result in damage.

Power Supply

The power supply is a self-contained unit housed in a steel case.
It has a selectable input voltage of 115 or 230VAC 50/60 Hz and an output voltage of 12 VDC power for distribution within the analyser.

Note: Input voltage can be manually changed by sliding 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 the rear of the instrument).

Communications

Communication between the analyser and either a data logger, laptop or network can be performed with the following communication connections located on the back panel (see Figure 5,).

RS232 #1

This port is designed to be used for simple RS232 communication.

RS232 #2

This port is designed to be used for simple RS232 communication, or in multidrop configuration.

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

Analog Inputs

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

CAUTION

Exceeding these voltages can permanently damage the instruments and void warranty.

Digital Status Inputs

The analyser is equipped with 8 logic level inputs (0–5VDC) for the external control of zero/span calibration sequences.

CAUTION

Exceeding these voltages can permanently damage the instruments and void warranty.

Digital Status Outputs

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

Bluetooth

This allows for remote access of the analyser to any Android device with the “Serinus Remote” Application installed on it. Uses Bluetooth to control the analyser, view parameters, download data and construct real-time graphs.

This page is intentionally blank.

Installation

Initial Check

Packaging

The Serinus 40 is transported in packaging which is specifically designed to minimise the effects of shock and vibration during transportation. Ecotech recommends that the packaging be kept if there is a likelihood that the instrument is going to be relocated.

Note: The red plastic caps that seal the pneumatic connections during transport must be removed prior to operation.

Opening the Instrument

To check the interior of the instrument:

1. Undo the screws located in the rear panel.
2. Open the chassis lid by releasing the latch (pressing the button) located on the front panel in the top left-hand corner, then slide the lid backwards.
3. To completely remove the lid, slide the lid backwards until the rollers line up with the gaps in the track and pull the lid upwards to remove from the instrument (Refer to Figure 4).
4. Check that all pneumatic and electrical connectors are connected.
5. Check for any visible and obvious damage. If damage exists contact your supplier and follow the instructions in Claims for Damaged Shipments and Shipping Discrepancies at

the front of this manual.

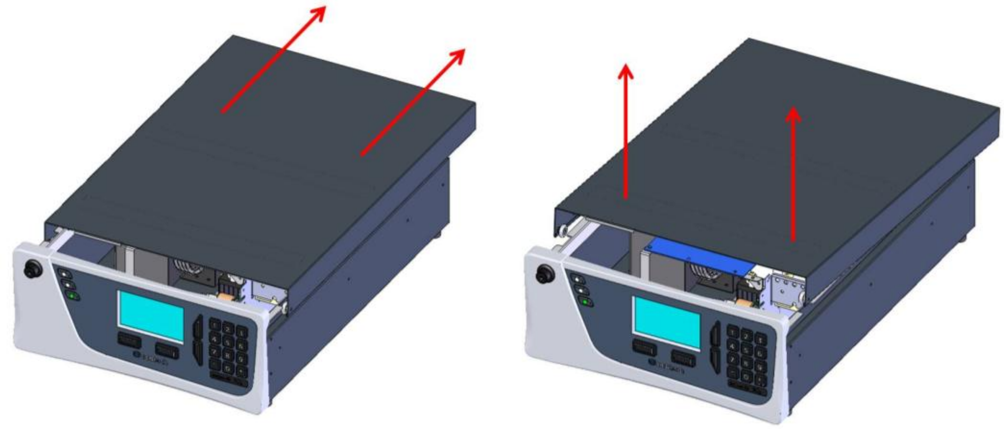


Figure 4 - Opening the instrument

Items Received

With the delivery of the Serinus 40, you should have received the following:

• Ecotech Serinus 40 instrument		PN: E020040
• Software CD		PN: S040001
• Manual		PN: M010028 (hardcopy optional)
• USB Stick		PN: H030021
• Power Cord (120V)*		PN: C040007
• Power Cord (240V)*	Australia	PN: C040009
Europe	PN: C040008	
UK	PN: C040010	

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

Note: Please check that all these items have been delivered undamaged. If any item appears damaged, please contact your supplier BEFORE turning the instrument on.

Mounting/Siting

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

- The analyser should be placed in an environment with minimal dust, moisture and variation in temperature (20-30°C for U.S. EPA designated range).
- For best results the analyser should be located in a controlled environment with temperature and humidity controlled (air conditioned shelter) set to 25-27°C.
- Whether in a rack or placed on a bench, the instrument should not have anything placed on top of it or touching the case.

- Instruments should be sited with easy access to the front panel (instrument screen/USB flash) and to the back panel (Communication ports/pneumatic connections).
- It is recommended that sample line be as short as possible and/or a heated manifold be used for sampling (minimising moisture condensation in the sample).
- Do not pressurise the sample line under any circumstances. Sample should be drawn through the instrument under atmospheric pressure. This should be done either by the internal pump option (if installed) or by an external vacuum pump connected to the exhaust port of the analyser.
- When supplying span gas, ensure the flow is approximately 1.2 lpm and excess is sufficiently vented.

Note: The power on/off switch is accessible from the rear of the instrument only. Site the analyser so that the on/off power switch is accessible.

Instrument Set-up

After siting the instrument the following procedures should be followed to ready the analyser for monitoring.

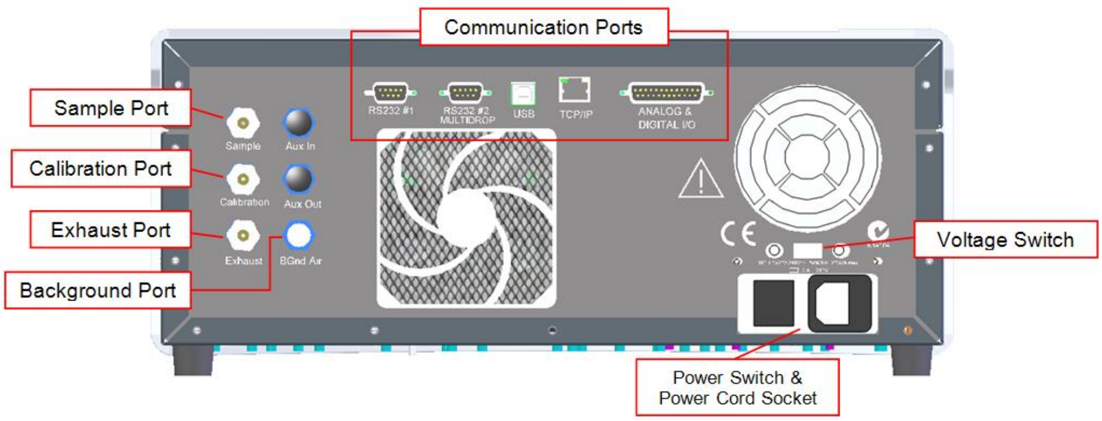


Figure 5 - Instrument back panel

Pneumatic Connections

The Serinus 40 contains 4 pneumatic ports on the back panel of the analyser; the sample port, the calibration port, the exhaust port and the background air 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 the inlet port nut, then insert the tubing through the back of the nut with the tube extending 1 inch through front.
- Place the tubing into the port until it hits the tube stop inside fitting.

- Place the nut back onto the fitting and tighten until (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 slpm delivered to the sample manifold (0.6 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.

Note: All connections to this port should not exceed ambient pressure. Vent is required for excess span gas.

Exhaust port

The sample air is expelled from the analyser through the exhaust port.
The exhaust tubing should be fitted to a vacuum pump (minimum: 1.2 SLPM at 50 kPa).

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 and away from the sample inlet.

Background

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

Power Connections

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

CAUTION
The following points MUST be followed. Incorrect setup and activation of the instrument may cause damage and will void the warranty.

1. Verify that the red switch (above power switch) is switched to the correct setting (230V or 110V).
2. A three pin power plug (with ground) MUST be used with an earthed power socket (3 pin).
3. Connect the power plug into the mains power point and turn the power switch on.

Communications Connections

There are a number of ways to communicate with the analyser:

RS232 #1

Connect this port to a data logger (such as WinAQMS) with an RS232 cable.

RS232 #2

Connect the RS232 cable from the instrument to a computer, datalogger or in a multidrop formation.
This is used to configure the computer/datalogger software for data export/remote control.

Note: When using multidrop ensure each analyser is given a unique instrument ID.

USB

Connect a USB cable to computer and run either the Serinus downloader program or an Ecotech WinAQMS data logger.

TCP/IP (optional)

Plug in a network cable (this cable should be attached to a network) and use the Serinus downloader program to access the instrument and download data. The Serinus downloader is supplied on the Utilities CD provided with the instrument.

Analog/Digital

This port is used to send and receive analog and digital signals. It is normally used to connect with a gas calibrator or to activate alarm signals.
Each instrument contains 8 digital inputs, 8 digital outputs, 3 analog inputs and 3 analog outputs.

Bluetooth

Connection is enabled using Ecotech's "Serinus Remote" Android Application.
Use the "Serinus Remote" Android Application to access instrument and download data. It is available for download directly from the Google Play Store. Search for "Ecotech Serinus Remote".

Analyser Set-up

1. Ensure the USB memory key is installed.
2. Check the battery is turned on at the main controller PCB (refer to Figure 6).
3. Turn on the instrument and allow it to warm-up.
4. Check/Set time and date (refer to Section 0).
5. Set the digital filter to the desired monitoring option.
6. Set the internal data logging options.
7. Set the analog/digital inputs and outputs settings.
8. Leave the instrument to warm-up and stabilise for 2-3 hours.
9. Perform a pressure sensor check (refer to Section 0).
10. Perform a leak check (refer to Section 0).
11. Perform a multipoint calibration (refer to Section 0).
12. The instrument will now be ready for operation.

U.S. EPA Equivalent Set-up

The Serinus 40 is designated as reference method RFNA–0809–186 by the U.S. EPA (40 CFR Part 53) The Serinus 40 must be used under the following conditions to satisfy its equivalency:

Range: 0-0.050 ppm and 0-1.0 ppm
Ambient temperature: 20-30°C
Line voltage: 105 to 125 VAC, 60 Hz
Pump: Ecotech optional internal or external pump
Filter: 5 micron PTFE filter must be installed in front of the sample inlet (zero and span gas must pass through this filter)

- If the units in the measurement menu are changed from volumetric to gravimetric (or gravimetric to volumetric), the analyser must be re calibrated.
- The analyser must be operated and maintained in accordance with this user manual.

The following menu selections must be used:

Calibration Menu
Span comp: Disabled
Diagnostics Menu
Pres/Temp/Flow comp: On
Diagnostic mode: Operate
Control loop: Enabled

The Serinus 40 analyser is designated U.S. EPA Equivalent method with or without the following options/items:

- Internal pump.
- Rack mount assembly.
- Internal zero/span assembly (IZS).
- Optional Ethernet port.

EN Type Approval Set-up

The Serinus 40 has been certified to MCERTS Performance Standards for Continuous Ambient Air Quality Monitoring Systems. The certificate number is Sira MC 100167/02. The Serinus 40 must be used under the following conditions to qualify as equivalent:

Range (NO): 0-1000 ppb
Range (NO_2): 0-260 ppb
Ambient temperature: 0-30°C

The analyser must be operated and maintained in accordance with this user manual.
The following menu selections must be used:

Calibration Menu
Span comp: Disabled
Service→Diagnostics Menu
Pres/Temp/Flow Comp: On

Diagnostic mode: Operate
Control loop: Enabled

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.
When transporting or storing the instrument the following points should be followed:

1. Turn off instrument and allow it to cool down.
2. Remove all pneumatic, power and communication connections.
3. If storing over long period (6 months) turn the battery off by switching the switch on the main processor board (shown in Figure 6) to the left.
4. Remove instrument from rack.
5. Replace red plugs into pneumatic connections.
6. Place instrument back in plastic bag with desiccant packs and seal bag (Ideally the bag it was delivered in).
7. Place the instrument back into the original foam and box it was delivered in. If this is no longer available find some equivalent packaging which provides protection from damage.
8. The instrument is now ready for long term storage or transportation.

Note: After transport or storage the instrument must be set up and calibrated (refer section 0.

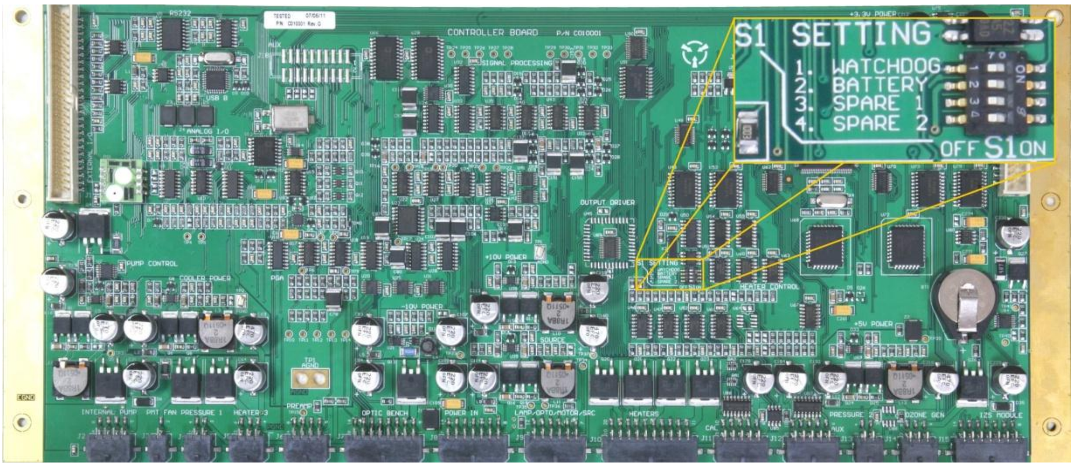


Figure 6 - Switching the battery off

Operation

Warm-up

The instrument requires 60 minutes for the NO_2 to NO converter to reach a temperature of 325°C at this temperature the ozone generator will be switched on and analysis of $NO/NO_2/NO_x$ will begin. No measurements are taken during the warm-up.
When the main screen appears, the instrument activity line will display the following warm up activities:

Adjust High Voltage

The high voltage digital pot is adjusted to set the high voltage supply to the PMT for optimal range and performance.

NO_2 converter is cold→ warm→ hot

The instrument progressively increases the temperature of the NO_2 to NO converter until it reaches the desired temperature 325°C. When heating from cold the NO_2 converter will take approximately 60 minutes to reach desired temperature.
After warm-up has completed the instrument will immediately begin taking measurements (refer to Section 0).

General Operational Information

The Serinus is operated with the use of 4 sets of buttons. There are the selection buttons (1), scrolling buttons (2), keypad (3) and traffic light indicators (4).

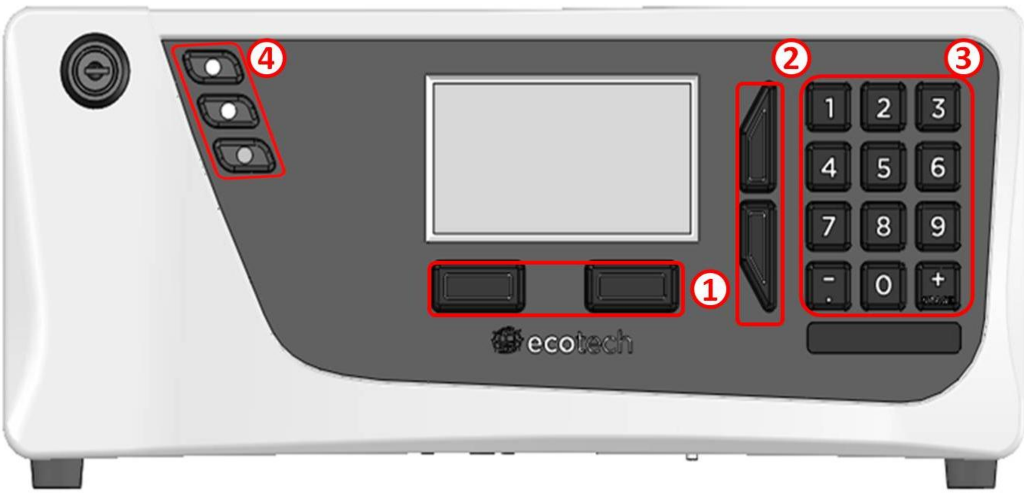


Figure 7 – Serinus front panel

Selection Buttons (1)

The selection buttons will perform the function specified directly above it on the screen. Generally this involves opening a menu, editing a value, accepting or cancelling an edit, or starting an operation.

Scrolling Buttons (2)

The scrolling buttons allow users to scroll up and down through menus or selection boxes. The scrolling buttons are also used to scroll side to side through editable fields such as: dates, times, numbers etc.
On the main screen these buttons are used for adjusting the screen contrast. Press and hold the up button to increase contrast; press and hold the down button to decrease.

Keypad (3)

The keypad contains numbers 0-9, decimal point/minus key ($\overset{-}{.}$) and a space/plus key ($\overset{+}{\text{SPACE}}$). The number keys are used to input numbers; in those cases where letters can be entered, the number keys act like a telephone keypad.

The ($\overset{+}{\text{SPACE}}$) and key ($\overset{-}{.}$) button functions depend on context. When editing a floating point number, the key ($\overset{-}{.}$) inserts a negative sign if the editing cursor is at the start of the number and negative signs are allowed. Otherwise it moves the decimal place to the current cursor location. The ($\overset{+}{\text{SPACE}}$) key inserts a positive sign if the cursor is at the start of the number; otherwise it enters a space.

For non-floating point numbers, these keys usually increment or decrement the current value by 1. When editing the month field of a date, the ($\overset{+}{\text{SPACE}}$). and ($\overset{-}{.}$) key change the month.

Instrument Status Lights (4)

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

- A flashing red light indicated that the instrument has a major failure and is not functioning.
- An orange light indicates there is a minor problem with the instrument, but instrument may still take measurements reliably.
- A green light indicates that the instrument is working and there are no problems.

In the case of a yellow or red light enter the "**Main Menu**" → "Analyser State" → "Status" menu to find which components are failing (refer to Section 7).
The green status button will cancel any open edit box or menu and return to the main display.
If no instrument status lights are on and the keypad is backlit, then this indicates that the instrument is running the bootloader.

Main Display

The main display is composed of seven parts: the readings, the error/status line, the time, the instrument activity line, selection buttons, the concentration units and USB status.

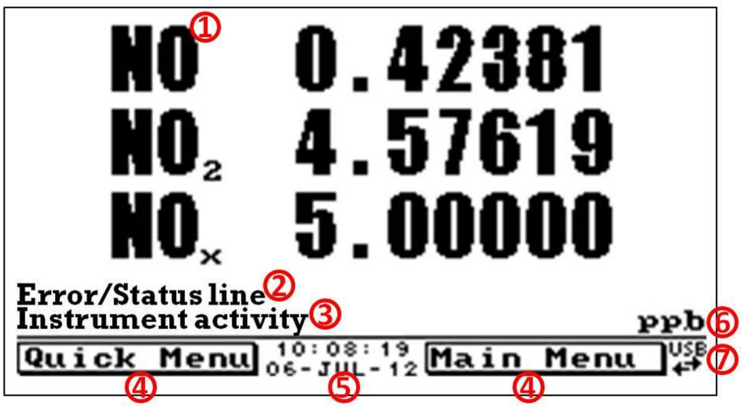


Figure 8 – Main screen display

Reading(1)

Displays the concentration being measured in real time. The display can be configured to show just the instantaneous data or the instantaneous and average data (refer to Section 0).

Error/Status Line (2)

The error/status line provides users with information on any problems the instrument may have. It includes all the errors and status conditions contained in the Status Menu (refer to Section 0).

Instrument Activity (3)

This line shows what function the instrument is currently performing. Generally, it will show three groups of actions; Warm-up, Measurement or Calibration.

Selection Buttons (4)

These buttons are used on the main screen to enter one of two menus. The **Quick Menu** (refer to Section 0) contains all information and features necessary for scheduled maintenance. The **Main Menu** (refer to Section 0) contains all information and fields available to users and is generally only used during initial setup.

Time and Date (5)

The Time and Date are displayed in between the menu buttons at the bottom of the screen.

Concentration Units (6)

The current instrument units are displayed in the bottom right hand corner of the display.

USB Detection (7)

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

Note: To safely remove the USB memory stick, navigate to the **Quick Menu** and use the "Safely Remove USB Stick" function.

Measurement

The Serinus 40 NO_X Analyser is a dual channel monitoring instrument which means that it measures sample air through two different paths. These two paths are used to measure NO (Sample) and NO_X (Sample Aux) with the NO_2 concentration resulting from a calculation of the difference between the two. The instrument measures NO and NOX in groups of 10 (5 of each), it swaps between the channel five times each per cycle.

Before each cycle, a background is performed to determine the level of fluorescence without NO present, thus removing any background noise from the signal.

The sampling procedure follows:

Table 1 - Sample cycle, 5 times per cycle

Sample Fill	3 sec	Cell fills with NO sample.
Sample Measure	3 sec	NO sample is measured.
Sample Fill Aux	3 sec	Cell fills with NO_X sample.
Sample Measure Aux	3 sec	NO_X sample is measured.

Table 2 - Background cycle, once per cycle

Background Fill	8 sec	Cell fills with background air.
Background Measure	3 sec	Background air is measured.
Background Purge	4 sec	Background air is removed from the cell and filled with NO

		sample.

Total cycle time is 75 sec.

Menus and Screens

The menu system is divided into two 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.
In general, editable parameters are displayed in bold font. Non-editable information is displayed in a thin font. Some parameters may become editable based on the state of the machine (for example, the manual "Cal. Mode" and" Port" can only be changed when the instrument is out of warm-up).

Quick Menu

The **Quick Menu** contains all the maintenance tools in one easy to use screen. It allows operators to perform calibrations, check important parameters and review the service history.

Span Calibrate

This field is used to perform a span calibration and should be only used when a known concentration of span gas is running through the measurement cell.

After activating 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.

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" (Normal instrument operation) or "In Maintenance" (data is not valid, as service work is being performed). This field is used to change the instrument into "In Maintenance" when service work is being performed.

Safely Remove USB

Before removing the USB memory stick, always select this menu item. (also occurs in the **Service Menu** 0). Failure to do this may cause corruption to the data on the memory stick.

Gain

This is a multiplication factor which is used to adjust the concentration measurement to the appropriate level (set by the calibration procedure). This must be recorded after each calibration in station log book.

Service Due

A 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** (refer to Section 0). This field is only displayed in the 2 weeks prior to the date displayed in this field, or after the date has occurred.

Main Menu

There are six menus on the **Main Menu** screen.

Analyser State	Refer to Section 0.
General Settings	Refer to Section 0.
Measurement Settings	Refer to Section 0.
Calibration Menu	Refer to Section 0.
Service Menu	Refer to Section 0.
Communications Menu	Refer to Section 0.

Figure 9 – Main menu

Note: Fields that are not bold (on the analyser screen) are non-editable.

Analyser State

This displays the status of various parameters that affect instrument measurement and various functions.

Status	Refer to Section 0.
Temperatures	Refer to Section 0
Pressures & Flow	Refer to Section 0.
Voltages	Refer to Section 0.
Event Log	This field enters a screen with a log of all the events that the instrument performs. These events include calibrations, errors, background measurements, warnings. This log is stored on the removable USB flash memory.
Firmware Version	This field displays the firmware version currently in use

	on this analyser. This can be important when performing diagnostics and reporting back to the manufacturer.
Instrument	This field displays the instrument model number.
Board Revision	This field displays the PCB board version.
Power Failure	This field displays the time and date of the last power failure (or when power was disconnected from the analyser).

Status

The **Status Menu** presents a list of the current “Pass/Fail” status of the main components. During start-up, the status of some parameters will be a dashed line.

Cell Temp	The cell temperature must be within ± 10% of the heater set point (refer to Section 0).
Valve Manifold Temp	The temperature of the valve manifold.
Converter Temp	The cell temperature must be between 250°C and 350°C to pass.
Cooler Status	Status of the PMT cooler must be 13°C ± 10% to pass.
Sample Flow	Indicates whether the instrument has sample flowing through it.
A/D Input	A reference voltage is sent to the analog to digital input chip; this field will display a pass or fail indicating if the board is working.
Chassis Temperature	Displays whether the chassis temperature is within the acceptable limits.
USB Memory Stick	Detects whether a USB memory stick is plugged into the front USB port.

Temperatures

Temperature control and reporting.

Temperature Units	Editable field to allow the user to change the current temperature units of the analyser (Celsius, Fahrenheit, or Kelvin).
Set Point (CELL)	Editable field that sets the target temperature that some heated components are regulated to.
Cell	Displays current temperature of the reaction cell.
Converter	Temperature of the NO_2 to NO converter.
Chassis	Displays the air temperature inside the chassis, measured on the main controller board.
PMT Cooler	Temperature of the cooled PMT block.
Manifold	Temperature of the orifice heater in the valve manifold.

Pressures and Flow

Pressure control and reporting display.

Pressure Units	Select the units that the pressure will be displayed in (torr, PSI, mBar, ATM, kPa).
Ambient	Current ambient pressure (outside the analyser).
Cell	Current pressure within the optical reaction cell.
Manifold	Current pressure in the valve manifold.
Sample Flow	Indicates the gas flow through the sample port of the instrument, should be around 0.50 (±2%).

Note: The sample flow will read 0.00 if the flow transducer detects that flow has stopped.

Voltages

Voltage reporting display.

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	Photo Multiplier Tube power high voltage supply 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.

General Settings

Decimal Places	Select the amount of decimal places (0-5) used for concentration on the front screen.
Concentration Units	Sets the concentration units. (ppm, ppb, ppt, mg/m^3,$\mu g/m^3$, ng/m^3).
Temperature Units	Select the units that temperature will be displayed.(Celsius, Fahrenheit, or Kelvin)
Pressure Units	Select the units that the pressure will be displayed in (torr, PSI, mBar, ATM, kPa).
Conversion Factor	This option only appears if concentration units are set to gravimetric. You can select either 0°C, 20 °C or 25 °C.
Date	Displays the current date and allows users to edit if required.
Time	Displays the current time and allows users to edit if required.
Backlight	Select how long the instrument backlight will stay on for either seconds (30), minutes (1, 2, 5, 10, 30), hours (1), or always on/always off.
Front Screen	This field allows the user to display concentrations on the front screen in two formats; the first is “Inst. only” which displays only the instantaneous concentration reading, the second is “Inst & Avg” which displays both

	instantaneous and average concentration on the front screen. The average is measured over the time period set in Measurement Settings (refer to Section 0).
Char 0 has Slash	When enabled, the instrument will display the zero character with a slash (ø) to differentiate it from a capital ‘O’.

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 (None, Kalman, 10 sec, 30 sec, 60 sec, 90 sec or 300 sec). **Note:** The Kalman filter is the factory default setting and must be used when using the instrument as a U.S. EPA equivalent method. The Kalman filter 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. **Note:** this function must be set to disabled for U.S.EPA approval.
Noise	The standard deviation of the concentration. The calculation is as follows: • Take a concentration value once every two minutes. • Store 25 of these samples in a first in, last out buffer. • Every two minutes, calculates 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 analyser for at least one hour.

Calibration Menu

Calibrating the instrument should be done with care. Refer to section 0 before using these menus.

Calibration 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 calibration will begin.

	• Whether the calibration will perform automatic compensation. • Manual calibration will perform a manual calibration depending on the calibration mode selected below. **Note:** Timed calibration with span comp enable **does not** fulfil U.S. EPA approval.
Calibration Mode	Displays the current mode the analyser is set to.
Calibration Port	This is only accessible once the instrument has completed warm up. Select whether the instrument will sample from the external span/zero source (Calibration port) or from the optional internal span/zero source (IZS).
Cycle Time	Displays the current calibration cycle time set in the **Calibration Menu**.
Span Calibrate	This field is used to correct the span calibration setting and 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 set.

Zero Calibrate NO	This field is used to correct the zero calibration setting on the NO channel. 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.
Zero Calibrate NO_2	This field is used to correct the zero calibration setting on the NO_2. 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.
Pressure Calibration	This field allows the user to calibrate the pressure sensors as explained in section 0.
Cal Pressure	This field displays the measured manifold pressure during the last calibration (for NO reference).
Cal Pressure 2	This field displays the measured manifold pressure during the last calibration (for NO_X reference).
Calibration Temperature	Temperature at which the instrument performed its last span calibration.
NO_2 Efficiency	The efficiency of the conversion of NO to NO_2.

Manual Mode

Calibration Mode (Only accessible once instrument has completed warm-up)	When in manual mode the instrument's operational mode can be chosen from the following: Measure: the normal measurement through the sample port. Zero: takes air through the calibration port so that a zero calibration can be performed. Span: takes air through the calibration port so that a span calibration can be performed. 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).
Cycle Time	The time period that the zero and span calibrations will last in "Cycle". Users can set the time from (5 to 59 minutes).

Timed Mode

Date	Enter the date for the next calibration to start.
Time	Enter the time that calibration will be performed. The time is set using a 24 hour clock.
Repeat	The calibration will be automatically run again after the specified amount of time. This field specifies the delay period (from 1 to 20,000 units, as specified below).
Units	This is the units of the repeat delay period. Thus, a repeat of 3 and units of days means that a calibration will automatically be performed every 3 days.
Span Compensation	When "Enabled" the instrument will adjust the gain based on the span level, when set to "Disabled" no calculation is made. **Note:** Timed calibration with span compensation enabled does not fulfil both U.S. EPA approval and EN certification.
Span Level	Enter the concentration of span gas used during the timed span calibrations.
Cycle Time	The time period that the span calibration will last. (1 to 59 minutes). This is editable.

Service

The **Service Menu** displays diagnostic information. The settings return to the previously set conditions when the operator leaves this menu.

Diagnostics	Refer to Section 0
Calculation Factors	Refer to Section 0

Ozone Generator	This field allows the user to turn the zone generator on and off. Note: The ozone generator will not be active if there is a flow fault due to safety reasons
Save Configuration	Saves all of the EEPROM-stored user-selectable instrument configurations to the USB memory stick (calibration and communication settings, units, instrument gain etc). If you have problems with your instrument use this function to save settings to the removable USB stick and send this file (and the parameter list) to your supplier with your service enquiry.
Save Parameter List	Saves a text file of various parameters and calculation factors. If you have problems with your instrument use this function to save settings to the removable USB stick and send this file (and the Configuration) to your supplier with your service enquiry.
Load Configuration	Loads a configuration file from the USB memory stick. Thus, you can save a configuration and restore it later.
Auto-Backup	Selects whether the parameter and configuration files are automatically saved once a day (at midnight).
Load Auto-Backup Configuration	Loads the auto-backup configuration file. This is useful when the configuration has been changed in error.
Instrument	This field allows the instrument to be set to either “Online” (Normal instrument operation) or “In Maintenance” (data is not valid, as service work etc is being performed).
Next Service Due	User editable field to set the date when the next instrument service is required. Section 0 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** (refer to Section 0).
Safely Remove USB Stick	This feature must be activated to safely remove the USB stick (also found in the **Quick Menu** (refer to Section 0)).
System Restart	Activating this will reboot the microprocessor.

Diagnostics

The **Diagnostics Menu** allows the user to gain a greater insight into what the instrument is doing.

Digital Pots	Refer to Section 0
Valves Menu	Refer to Section 3.5.16
Tests	Refer to Section 0
Pressure/Temperature/Flow Comp	Set to either “On” or “Off”. • “On” is used to compensate analyser measurements

	for environmental fluctuations that might affect readings (pressure, temperature and flow). • "Off" is used only when running diagnostics to see fluctuations in readings.
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.

Control Loop	When "Enabled" the instrument will control all processes within the instrument. Selecting "Disabled" pauses the instrument control over certain processes and parameters (e.g. digital pots). The user can now manually alter and adjust digital pots without the microprocessor overwriting the changes. **Note:** Turning off the control loop will disrupt normal data logging.

Digital Pots

Pots are electronically controlled digital potentiometers used for adjustments to operations of the analyser. This menu should be accessed only during diagnostics.
Unless the control loop is turned off (refer to Section 0), changes to the pots will be modified by the microprocessor. This is intentional; some diagnostics are best done with instrument feedback, and some are best done with the instrument inactive.

High Volt Adjust	(130-150)	
High Voltage	(640-670)	
PGA Gain	(1-128)	Displays gain of the ADC for the measurement cell.
Input Pot	(104)	Input gain.
Conc Voltage (RAW)	(0-3)	The voltage measured by the analog to digital converter.
Conc Voltage	(0-3)	The voltage after adjustment by the PGA gain factor.
Test Pot	(0)	This pot is for diagnostics only.

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 "Enabled" the instruments valves will open and close under microprocessor control. When "Disabled" the valves will change only in response to manual controls. Manually changing a valve while sequencing is enabled does not prevent the microprocessor from changing it

	again. Valve sequencing will remain off unless the instrument has returned to main screen for longer than 2 minutes.
NOx Select	Shows the current operation of the NOx select valve. This valve switches the NO_2 to NO converter sample to flow either through to the cell, or to bypass the sample out of the exhaust port of the instrument. Open = sample via NO_2 converter. Closed = bypass NO_2 converter sample out of instrument.
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. Selecting switch will change the valve to the alternative state (open = sample via sample port only, closed = sample port via NO_2 converter.
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. This 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 the Internal Zero. Open = Internal zero, Closed = Calibration port.
Pressurised Span (optional)	Shows the action of the valve that determines whether the instrument calibration gas is taken from the optional pressurised span port.
Pressurized Zero (optional)	When "Closed", the Aux-In port is blocked. When "Open," the Aux-In port is open (refer to Section **0**).

Tests

Screen Test	Performs a screen test by drawing lines and images on the screen so that the operator can determine if there are any faults in the screen. Press the left or right key to step through the test. The up and down arrow keys will adjust the contrast.
Digital Inputs	Displays the status of the 0-7 digital input pins. Value will be a 0 or a 1.
Digital Outputs	This menu item allows the user to view the pins that digital outputs are located on. The output can be

	switched on and off to test the connection. **Note:** Entering either the **Digital Inputs** or **Digital Outputs Menu** will temporarily disable all digital and analog input/outputs. This will affect logging via these outputs. Exiting the menu restores automatic control.
Analog Inputs & Outputs	Displays the pins that analog inputs are located on and allows the user to set the analog outputs.

Calculation Factors

The calculation factors provide the values used to calculate different aspects of measurement and calibration. The following fields are found in one, two or all of these sections and only the Pressure, Temperature, Flow (PTF) correction fields are non-editable.

Instrument Gain	A multiplication factor used to adjust the concentration measurement to the appropriate level (set at calibration).
Zero Offset (NO and NO_2)	This field displays the offset created from a zero calibration. This is the concentration measured from zero air and is subtracted from all readings.
Background (NO)	The correction factor calculated from the background cycle (used to eliminate background interferences).
PTF Correction (NO and NO_2)	Displays the correction factor applied to the concentration measurement. This correction is for changes in pressure, temperature and flow.
Conv. Efficiency (NO_2)	The efficiency that the converter converts NO_2 into NO (%).

Communications Menu

Configures how the instrument communicates with external instrumentation and data loggers.

Data Logging Menu	Refer to Section 0
Serial Communications	Refer to Section 3.5.21
Analog Input Menu	Refer to Section 0
Analog Output Menu	Refer to Section 0
Digital Input Menu	Refer to Section 0
Digital Output Menu	Refer to Section 0
Network Adaptor Menu	Refer to Section 0
Bluetooth Menu	Refer to Section 0

Data Logging Menu

Data Log Set-up – Numeric	This allows up to 12 parameters to be logged. After each parameter (labelled “Logging Param. 1” – “Logging Param. 12”) place the number of the parameter that is to be logged. A 255 indicates the end of the list of parameters to be logged.
Data Log Set-up – Test	This is an alternate and easier way to select logged parameters. Instead of entering a number, select the item by name from a list. Select the blank line to indicate the end of the list of parameters to be logged.
Data Log Interval	Set the interval that measurement data will be logged at. (1 second to 24 hours) or Disabled which means that no data is logged by the USB memory stick. **Note:** It takes about 1/3 of a second to log a measurement, selecting the 1 second interval may slow down serial communications.
+/- Keys	The list of parameters must be contiguous. Thus, when you delete a logging parameter, any parameters below it will be moved up. The ‘–‘ key will also delete the currently highlighted parameter; the ‘+’ key will insert a new parameter at that location, moving the others down.

Serial Communications

Multidrop ID	This is the ID of the analyser when multidrop RS232 communications is used. This defaults to 40 but can be changed if multiple Serinus instruments are on the same RS232 cable.
Delay (RS232#2)	When set to “Enabled” it will delay the serial communication through the RS232 #2 port by approximately 0.25 seconds. This is used in systems that cannot cope with the rapid response of the Serinus instruments. When set to “Disabled” communication will proceed without delay.
Baud (RS232 #1)	Sets the baud rate for this serial channel (1200, 2400, 4800, 9600, 14400, 19200, or 38400).
Protocol (RS232 #1)	Sets the protocol used for this serial channel (EC9800, Bavarian, Advanced, or Modbus).
Baud (RS232 #2)	Sets the baud rate for this serial channel (1200, 2400, 4800, 9600, 14400, 19200, or 38400).
Protocol (RS232 #2)	Sets the protocol used for this serial channel (EC9800, Bavarian, Advanced, or Modbus).

Analog Input Menu

The Serinus supports 3 analog inputs from the 25 pin I/O connector. Each input is a 0 to 5 volt input that can be scaled and then logged to the internal memory, or accessed remotely

	as parameters 199-201.
Input 1/2/3 Multiplier	The input voltage will be multiplied by this number. Eg if a sensor has a 0-5V output for a temperature of -40°C to 60°C, then the multiplier would be (60-(-40))/5 = 20.
Input 1/2/3 Offset	The value will be added to this input. Continuing the example in the multiplier description, the offset should be set to -40, so that a voltage of 0V, will be recorded as -40°C.
Input 1/2/3 Reading	The current reading from the input voltage, after the multiplier and offset have been applied. This is the value that would currently be logged, or reported as parameter 199-201 via USB or serial requests.

Analog Output Menu

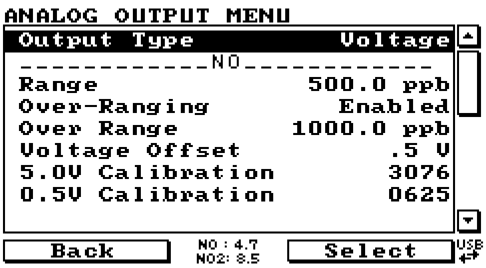


Figure 10 – Analog output menu – voltage.

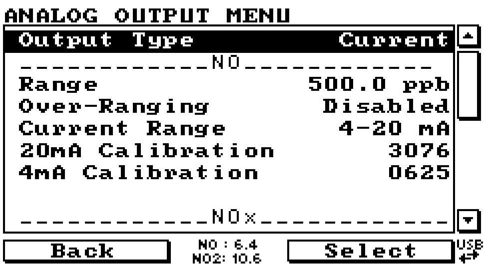


Figure 11 – Analog output menu – current

Output Type	The output can be set 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 the upper range limit (in concentration units) to desired 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 the 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).
Voltage Offset	Choices are 0V, 0.25V, and 0.5V. Recorder or data logger output will reflect this.
5.0V Calibration	Enables the user to calibrate the analog output at a full scale point.
0.5V Calibration	Enables the user to calibrate the analog output at a low point.
Current Range	Enables the user to set desired current ranges. Choices are 0-20mA, 2-20mA or 4-20mA.
20mA Calibration	Enables the user to calibrate the current output at a full scale point of 20mA
4mA Calibration	Enables the user to calibrate the current output at a low point.

Digital Inputs Menu

This menu is used to remotely trigger zero and span calibrations. This is done by assigning the 8 digital inputs with one of the following commands.

Disabled No action taken
Do Span Perform a span check
Do Zero Perform a zero check

The input is triggered with an active low. The actual digital input pin-outs are listed in the menu.

Example

Here is an example for a typical configuration between an analyser and either a data logger or calibrator (master device):

1. Set the jumper JP1 to 5V position see section 0
2. Connect one of the master devices digital output signal to pin 18 and the ground signal to pin 5 of the analyser’s analog /digital 25 pin female connector. See section 0.
3. Program master device to output 0 volts to pin 18 when a span is desired.
4. In the analyser’s **Digital Input Menu** assign DI 0 Do Span.
5. The same procedure can be followed to also activate zero calibrations.

Pin 6 of the analysers analog/digital 25 pin female connector can be connected to one of the other master devices digital outputs and the analyser can be set so DI 1 is assigned to “Do Zero”.

Digital Outputs Menu

This allows the analyser to trigger external alarms in response to certain events.
There are 8 different pins available, which will be set high during an associated event:

- Disabled (never triggered).
- Power Supply Failure.
- Ref Voltage Failure.
- A2D Failure.
- Lamp Failure.
- Flow Heater Failure.
- Lamp Heater Failure.
- Chassis Temp Failure.
- USB Disconnected.
- Background.
- Span.
- Zero.
- System.

Assign the digital outputs 0-7.

Network Adaptor Menu

The **Network Adaptor Menu** allows the user to view or set the I.P. address, Netmask and Gateway if the optional network port is installed.
To read the IP address, perform the following steps:

1. Set the instrument to Read IP.
2. Manually cycle power off.
3. Wait 3 seconds.
4. Turn power on.
5. Read or set the IP address.

Start-up Mode	The following modes are available:
Normal	In this mode nothing is done with the network port during boot-up. It is assumed to be configured correctly or unused.
Read IP	This mode interrogates the network port for its IP address. The menu will display this address after boot-up.

Set IP	You may enter an IP address, Netmask, and Gateway address (following the usual rules for formatting these addresses). Please note that at this time the Serinus does not validate the correctness of these entries. When you cycle power, the Serinus will first instruct the network port on its new address. It will then switch to Read IP mode and read back the address it just set so that you may verify it in the menu.
Set DHCP	This sets the network port into DHCP mode, effectively setting its IP address to 0 and allowing the network to assign the Serinus an IP address.

Bluetooth Menu

Serinus instruments manufactured after 2012 support Bluetooth communication through the “Serinus Remote” Android Application (refer to Section 0).

Bluetooth	This field indicates whether the analyser is remotely connected to an Android device.
Reset Bluetoooth	After changing the ID or PIN. Reboot the Bluetooth module. This is done by resetting the instrument or by using this menu item to reboot only the Bluetooth.
ID	This is the Bluetooth ID of the analyser. In edit mode the number keys act like a telephone keypad. Every time a number key is pressed, it cycles through its choices. The up/down arrow keys scroll through all the numbers and the entire alphabet. 1 = 1 or space 2 = 2, A, B, C, a, b, c 3 = 3, D, E, F, d, e, f 4 = 4, G, H, I, g, h, i 5 = 5, J, K, L, j, k, l 6 = 6, M, N, O, m, n, o 7 = 7, P, Q, R, S, p, q, r, s 8 = 8, T, U, V, t, u, v 9 = 9, W, X, Y, Z, w, x, y, z 0 = 0 or space The default setting is the Serinus ID/Serial Number. Note that the word “Serinus” is always the first part of the name and cannot be edited.

PIN	This is a passcode/pin required for the "Serinus Remote" Application to connect to the analyser. The default passcode/pin is "1234".

Communications

The Serinus can perform communication through 5 different paths; RS232, USB, 25 pin digital/analog input/output, TCP/IP network (optional) or Bluetooth. The "Serinus Downloader" application allows data downloads and remote activation from a PC.

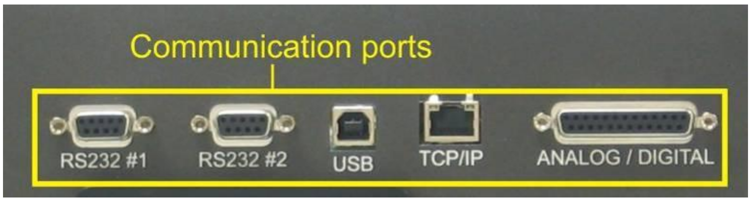


Figure 12 - Communication ports

RS232 Communication

RS232 communication is the most versatile way to access data from the instrument. Port #1 directly interfaces with the RS232 port. Port #2 supports multi-drop. This is a configuration of multiple analysers connected via the same RS232 cable. Verify that the "Multidrop ID" is set to either 0 (for direct connection) or a unique value which is different to the other analysers in the chain (refer to Section 0).
The Serinus supports the following protocols:

- Advanced protocol (Appendix A)
- EC9800 protocol (Appendix B)
- Bavarian protocol (Appendix C)
- ModBus protocol (Appendix D)

USB Communication

This port is a faster version of the RS232 serial port, which uses a USB connection.
It supports the following protocol:

- Advanced protocol (Advanced Protocol Parameter List)

TCP/IP Network Communication (Optional)

This port is best used for remote access and real-time access to instruments when network connectivity is available.
It supports the following protocol:

- Advanced protocol (Appendix A)

Configuring the network port requires setting the IP address. This is done via the **Network Adaptor Menu** (refer to Section 0).

Digital/Analog Communication

The 25 Pin Analog/Digital port on the rear of the analyser 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 analyser is equipped with three analog outputs that can be set to provide either Voltage (0-5V) or Current (0-20, 2-20, 4-20 mA). The analog outputs are tied to the instrument measurements:

Table 3 – Analog outputs

Analyser	Output 1	Output 2	Output 3
S10	O_3	N/A	N/A
S30	CO	N/A	N/A
S40	NO	NO_2	NO_X
S44	NO	NH_3	NO_X
S50	SO_2	N/A	N/A
S51	SO_2	H_2S	N/A
S55	H_2S	N/A	N/A
S56	TS	N/A	N/A
S57	TRS	N/A	N/A

Analog Output Calibration Procedure

1. Connect a volt meter (using an appropriate adaptor or probes on the volt meter) to the ground (pin 24) and the relevant output pin (pin 10)
2. Navigate to the **“Communications”→Analogue Output Menu**
3. Adjust the “0.5V Calibration” value until the volt meter reads 0.500 +/ .002
4. Adjust the “5.0V Calibration” value until the volt meter reads 5.00 +/ .002

Analog Inputs

The analyser is also equipped with three analog inputs with resolution of 15 bits plus polarity, accepting a voltage between 0-5 V.

Digital Status Inputs

The analyser is equipped with 8 logic level inputs for the external control of the analyser 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 (refer to Section 0).

Digital Status Outputs

The analyser is equipped with 8 open collector outputs which will convey instrument status condition 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 () 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.

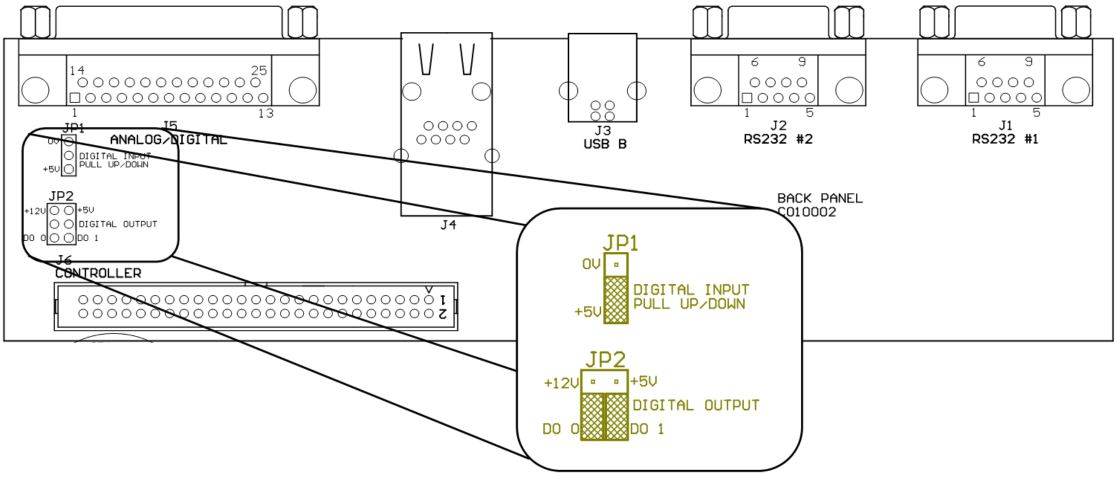


Figure 13 – Serinus 25-pin microprocessor board (with default jumpers highlighted)

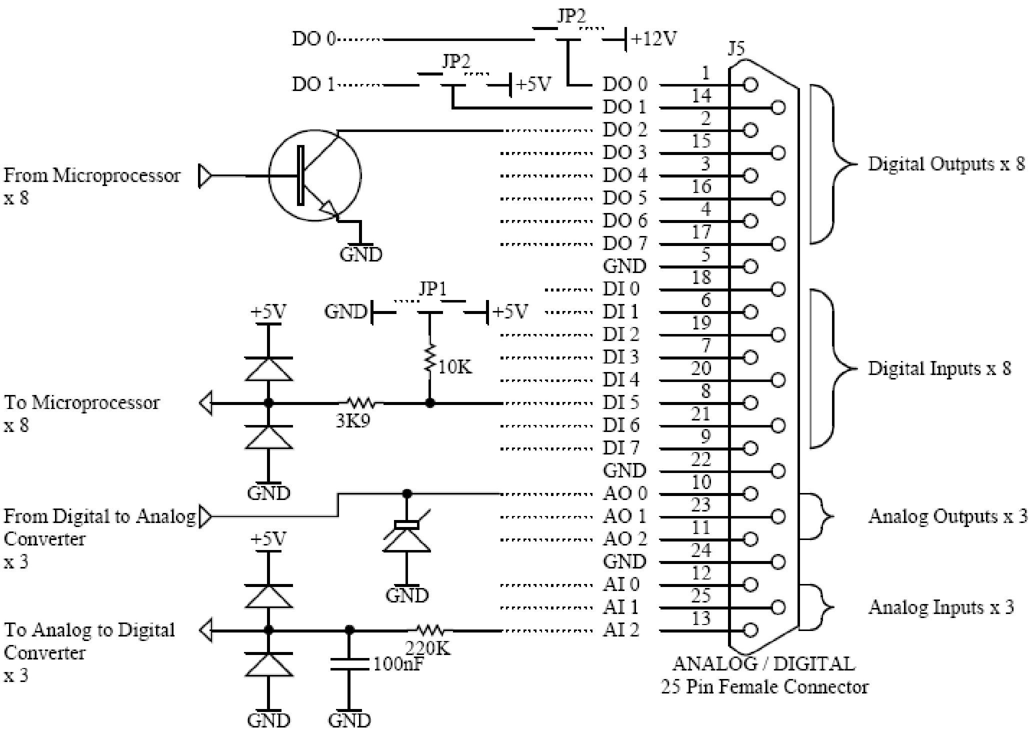


Figure 14 - External 25pin I/O individual pin descriptions

CAUTION

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 the warranty.

Serinus Downloader Program

The Serinus Downloader program is designed to allow the operator to acquire data directly from the analyser and control it remotely. The Serinus downloader program has four main windows:

- Settings: configurations are made to communicate with the analyser.
- Data: data is downloaded into a spread sheet format.
- Remote Screen: the analyser can be controlled remotely.
- Remote Terminal: a diagnostic tool used to check instrument operation and parameter values.

Settings

Within this window both the data format setting and analyser 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 file

Type in the destination (folder) including file name (extension must be .txt) for the data to be downloaded into.

Date Format

Type in the date format that data will be written (within the text file).
The format must be as specified; that is, 4 digits of year, 2 of month, 2 of day, 2 of hour, and 2 of minutes. The year digits are separated by slashes, the date and time fields are separated by a blank, and the hour and minute fields are separated by a colon.
The output data can be stored in one of three ways:

- Append Data: Add data onto the end of the current entries within the text file.
- Overwrite Data: Always create a new text file rather than adding to an existing file.
- Prompt User: Displays a window that prompts user to overwrite data. If ”No” is selected data will be appended to the current file.

Connection Type

Choose the connection to the analyser:

- Direct Serial Connection: The analyser is connected to the PC via a serial cable.

- Network Connection: The analyser is connected via a network.
- USB Connection: The analyser is connected directly to PC via a USB cable.

Port

The contents of this field depend on which connection you have made:

- Direct Serial Connection: Select a COM port.
- Network Connection: Enter the port number of the analyser (32785).

Baud

For a direct serial connection, this specifies the baud rate of the analyser (refer to Section 0).

IP Address

For a network connection, this specifies the IP address of the analyser (refer to Section 0).

Analyser

With a USB connection, the drop down list will display all of the connected analysers.

Analyser ID

For a multi-dropped direct serial connection you must supply the multidrop ID of the specific analyser (refer to Section 0). If only one analyser is connected, this field can remain 0.

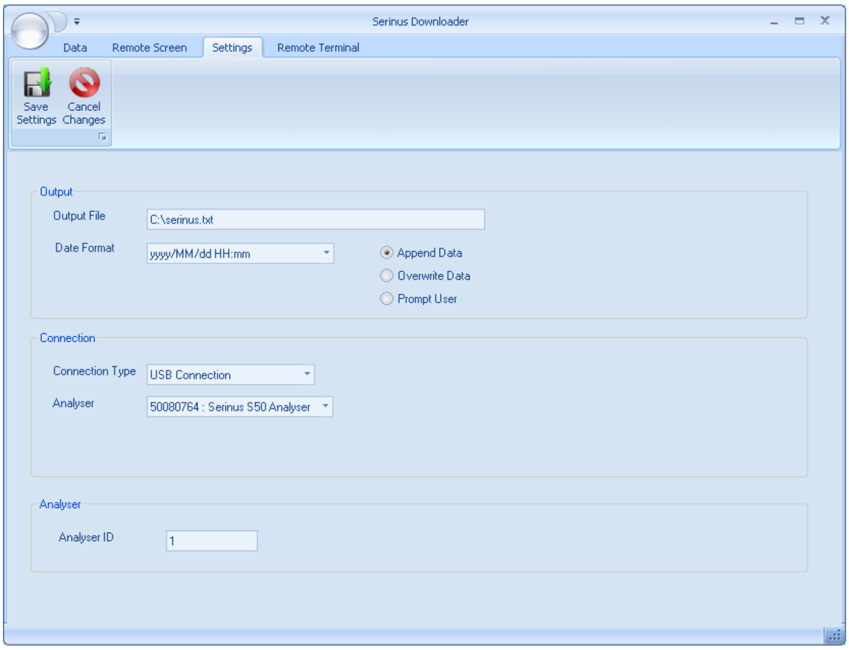


Figure 15 - Serinus downloader - Settings tab

Data

The data window presents a spread sheet with rows (numeric) and columns (labelled as per parameter). Refer to .

State Date/End Date

Specify the start and end time of the requested download. All data logged between these two times will be downloaded and displayed.

Acquire Data

Download the specified data.

Save Data

Save the downloaded data to a text file in Excel format.

Clear Data

Erase the downloaded data, allowing you to download a different set of data.

Rebuild Index

This function is obsolete and no longer used.

Reset Memory Stick

This function is obsolete and no longer used.

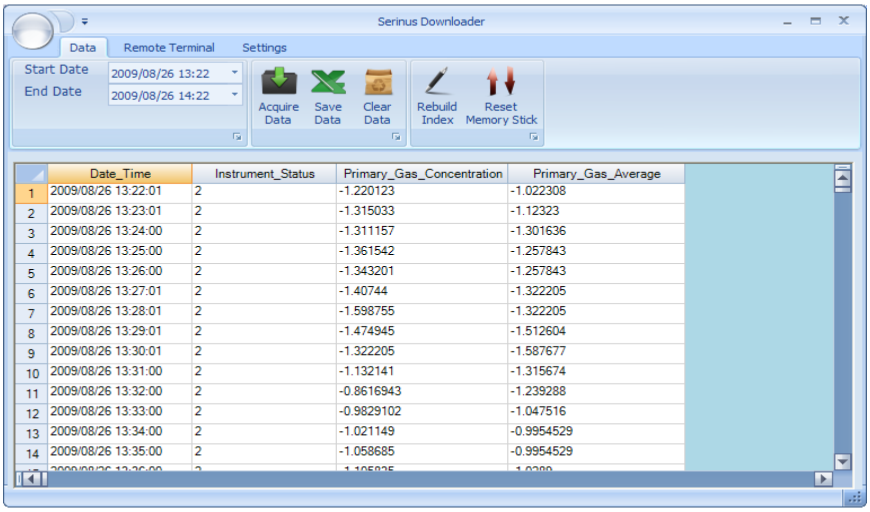


Figure 16 - Serinus downloader – data tab

Remote Screen

The remote screen tab allows the user to connect to the Serinus instrument and control it remotely.
If connecting via a serial cable, the Serinus must be in “Advanced” protocol for that serial port.

Connect

Connects to a Serinus and updates the display. The screen is not “live. It must be updated after every action. When you initiate an action (such as pressing a button) the screen will automatically update. However, if the Serinus changes state (such as changing the displayed concentration on the instrument screen), this change will not automatically appear on the Serinus downloader display. Use the “Refresh Screen” button to update the Serinus display without sending a keystroke.

Disconnect

Disconnects from the Serinus. This happens automatically if you exit the program. If you want to connect to a different Serinus, you will need to disconnect before you change the Settings tab.

Refresh Screen

Updates the downloader’s display with the most recent screen from the Serinus.

Display

The display area shows the screen as it appears on the Serinus. To navigate through the menus, click the left or right buttons on the screen, or use the escape and enter keys on the computer keyboard.
To scroll up or down, use the arrow cursor keys on the computer keyboard (the buttons on the display do not function).
To enter values click on the keypad next to the display or use the number keys on the computer keyboard.

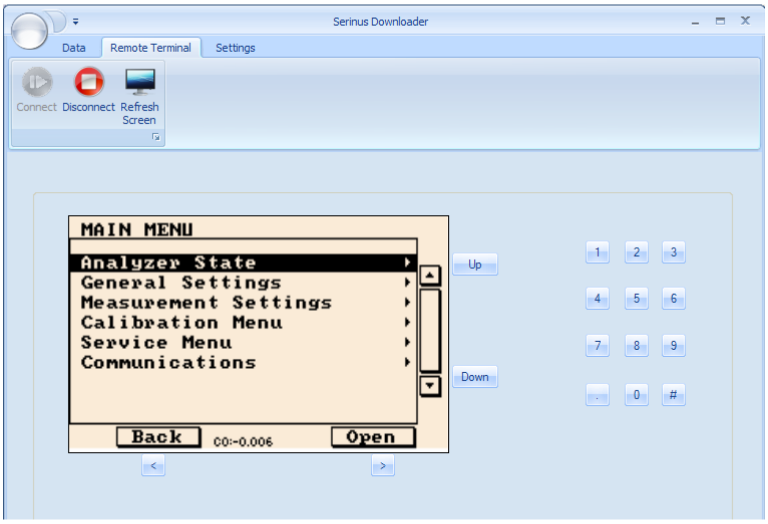


Figure 17 - Serinus downloader – remote screen tab

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 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:

Connect

Connects to the analyser. This button will be greyed out and disabled if the Downloader program is already connected via the remote screen.

Advanced Protocol

Assumes the Serinus is in advanced protocol. Enter a parameter number to retrieve and click “Get.”

EC9800 Protocol

Assumes the Serinus is in EC9800 protocol and the program is connected via a serial cable. Enter an EC9800 protocol command and click “Send.”

Received Data

Displays the received data. Values can be cleared by pressing the clear button.

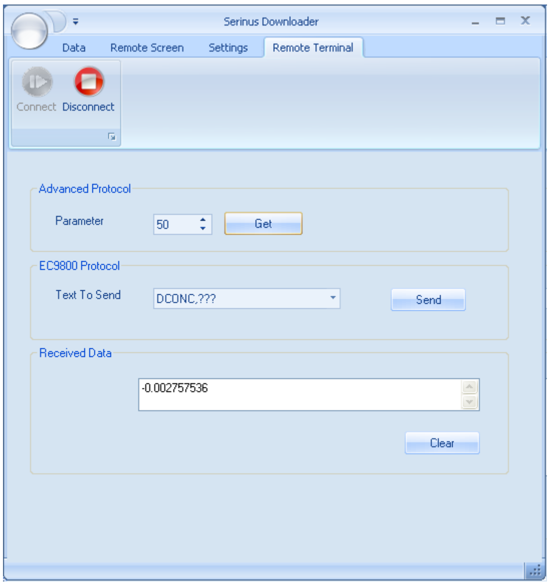


Figure 18 - Serinus downloader – remote terminal tab

Serinus Remote App/Bluetooth

Ecotech's Serinus Remote Application allows for any Android device (Tablet or Smartphone) to connect to an analyser.
Using the Serinus Remote Application the user can:

- Completely control the analyser using a remote screen displayed on the device.
- Download logged data and take snapshots of all the instrument parameters.
- Construct graphs from logged data or real time measurements.

Installation

The Serinus Remote app. can be found in the Google Play Store by searching for 'Ecotech' or 'Serinus'. Once found, choose "Install" the App. and "Open" to start the application.

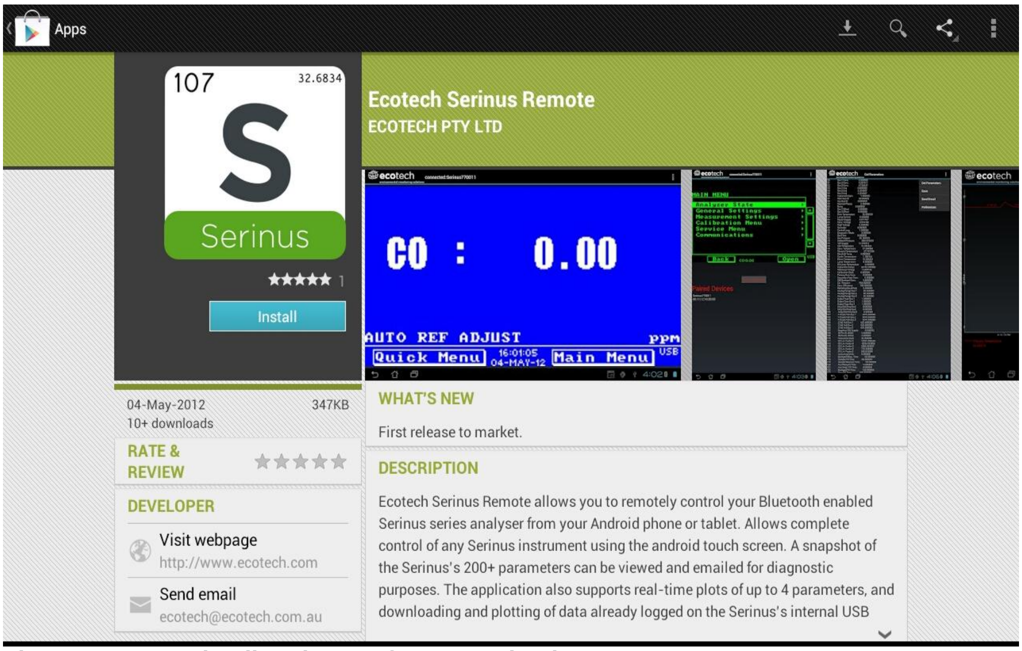


Figure 19 – Downloading the app from Google Play store

Note: A menu containing additional features and functions can be accessed by entering the **Options Menu** (or similar) on your device. The location and format of this menu may vary.

Connecting to the Analyser

Refer to the **Bluetooth menu** to find the Serinus analyser Bluetooth ID and PIN (refer to Section 0).

To connect to an analyser:

1. Touch the “Scan Serinus Analysers” button at the bottom of the screen.
2. Select the Analyser ID from either the “Paired Devices” or the “Other Available Devices”. (see ID in the **Bluetooth Menu**).
3. Input the PIN (if prompted to do so) then press “Ok”. (see PIN in the **Bluetooth Menu**).

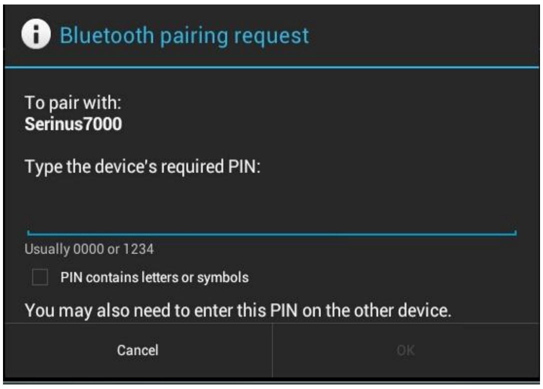


Figure 20 – Bluetooth pairing request

A screen shot of the analyser's current screen should appear on your smartphone or tablet. To disconnect press the "back" key/button on the device.

Note: Once the analyser has been paired with the device it will appear under "Paired Devices" and the PIN will not need to be entered in again in order to connect to the analyser

Control Serinus Analyser

Once connected the user has full control of the analyser. The range for remote control depends on the device's Bluetooth capabilities and any intervening obstructions, but is usually up to 30m.

Remote screen operation

With the exception of the number pad, all button functions/actions can be performed by touching the screen. This includes the selection buttons and the scroll buttons. Touching any part of the screen where there is not already a button also enacts the functions of the scroll buttons.

The "back" button will return to the Selection screen, allowing you to connect to a different analyser.

- Main Screen: Touching the upper half of the screen increases the contrast and touching the lower half of the screen decreases contrast.
- Menus: Touching the screen upper or lower half of the screen allows the user to scroll up and down respectively.
- Left-hand section of the screen: Swiping from right to left brings up the number pad for entering numbers (swipe from left to right to hide the number pad).

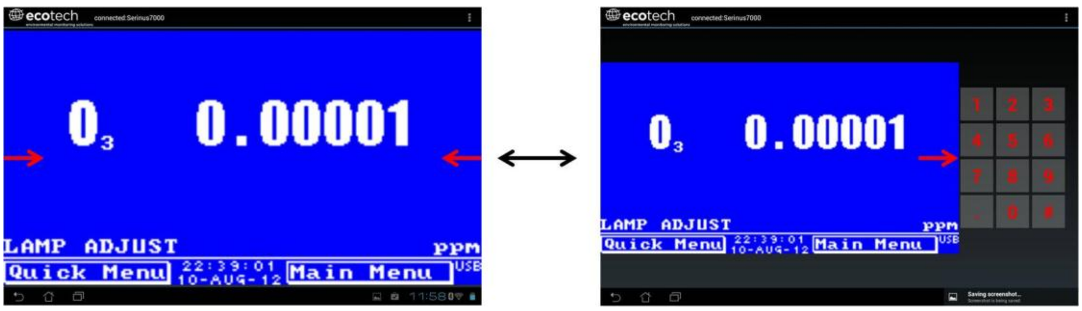


Figure 21 – Entering numbers into Serinus Application

- Right-hand section of the screen: Swiping from left to right brings up a list of available analysers (swipe from right to left to hide the analyser list).

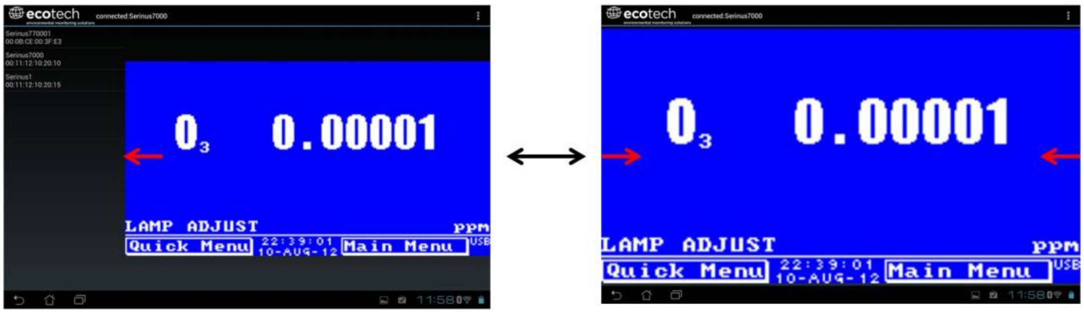


Figure 22 – Switching analysers in Serinus Application

Options menu

The "**Options**" menu is accessed by the grey button in the top right corner of the screen.

Refresh	Refresh the display
Show/Hide NumPad	Show or hide the Number Pad
Real Time Plot	Refer to Section 0
Download	
Get Parameters	Refer to Section 4.6.5
Preferences	Refer to Section 0

Real-time Plot

Allows user to view real-time plotting of selected parameter(s) and graph up to four parameters at the same time. The user can also scroll from left to right, top to bottom, or zoom in and out on the plot by swiping.
Once the plot is zoomed or scrolled, it enters into "Observer" mode, meaning that real-time updating is suspended. Press at the top of the screen to return to "Normal" mode, which will re-centre the plot and resume real-time updating.

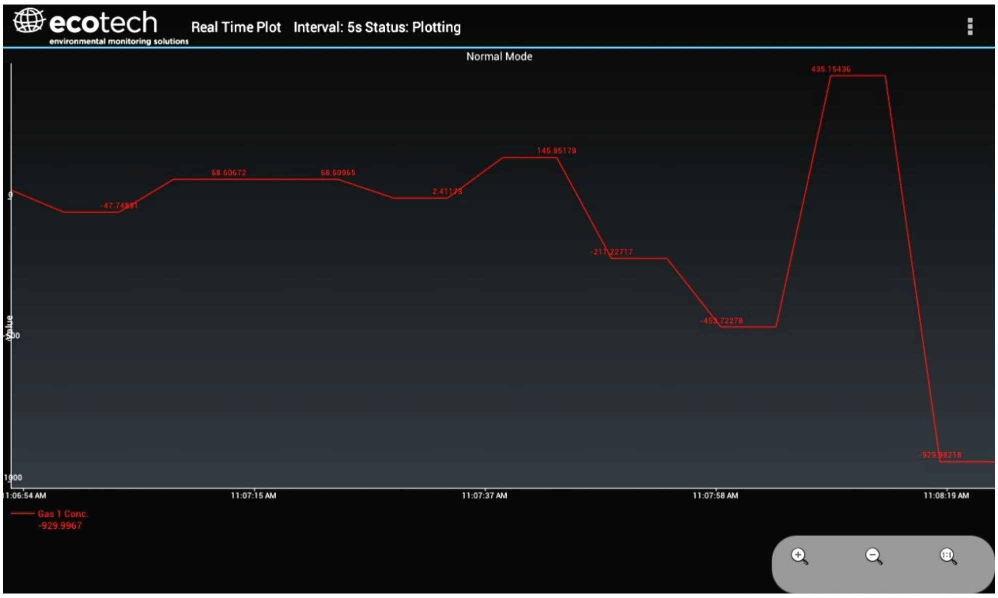


Figure 23 – Real-time plot

Options Menu

The "**Options**" menu is accessed by the grey button in the top right corner of the screen.

Start	Restarts graphing if it has been stopped and returns the graph to "Normal" mode.
Stop	Stops collecting data. In this mode you can scroll the display without going into "Observer" mode, because the system has no data collection to suspend. It is necessary to "Stop" data collection to set the interval.
Clear	Clears the window and restarts the graphing.
Save	Saves image of the graph and accompanying data in the location already specified in preferences. User will also be asked whether they want to send the file and data via email. When saving the data, you can choose to "Save All Data" or "Customise" the length of the data by entering a time between 5 minutes and 6 hours. Only the data from the start of collection to that limit will be saved (although the plot will still appear exactly as it does on screen).
Set Interval	While data collection is stopped, the user can specify the time intervals between collection.

Get Parameters

Downloads a list of parameters and corresponding values directly from the analyser.

Options Menu

Get Parameters	Refreshes the parameter list display.
Save	Generates a filename from the current date and time, saves the parameter data in the location already specified in preferences, and then asks to send the saved text file as an attachment to an email.
Send E-Mail	Sends an email with the parameter data in the body of the email, formatted as displayed.
Preferences	Refer to Section 0

Preferences

Preferences menu allows the operator to adjust the directory settings, the logs, format and the colour scheme settings. It can be accessed through the “**options**” menu in most windows.

Directory Settings

The operator can specify/select where to save the parameter lists, logged data and real time plots.

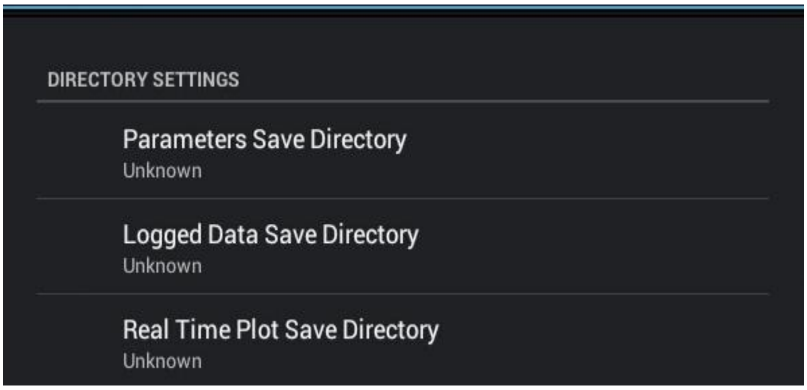


Figure 24 – Directory settings

Logs Format

When downloading logged data, the parameters can be displayed in one line or each in a separate line.

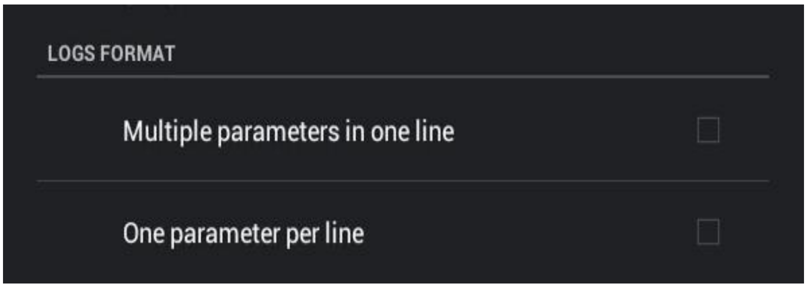


Figure 25 – Logs format

Colour Theme Settings

Allows the operator to choose a colour scheme for the remote screen. (“Matrix”, “Classic”, “Emacs” or “Custom”.

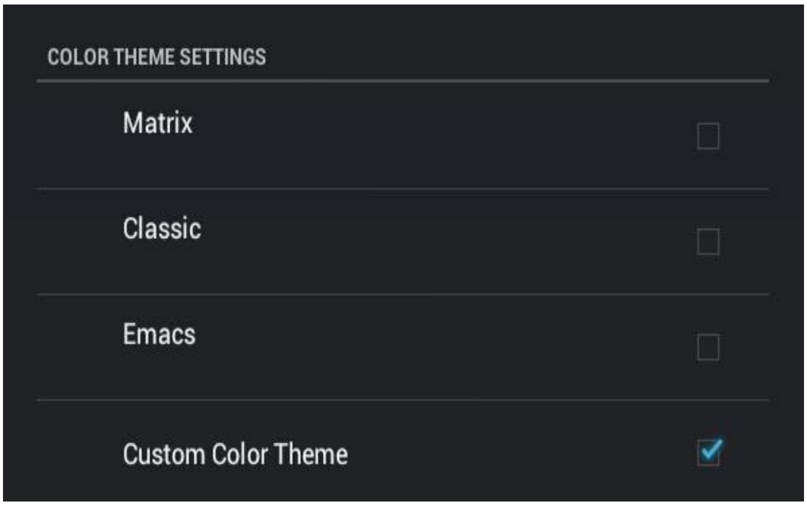


Figure 26 – Colour theme settings

This page is intentionally blank.

Calibration

These procedures describe how to calibrate the Span and Zero point for the analyser.
The following sections assume the instrument is in the **Calibration Menu** (refer to Section 0).

Zero Calibration

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

Note: This calibration is unnecessary and Ecotech recommends that the zero calibration only be used when specifically required.

A zero calibration can be performed through either the calibration port or the sample port. Follow the instructions below:

Calibration Port

1. Ensure a suitable zero source is connected to the **Calibration port** on the back panel of analyser (refer to Section 0).
2. Set “Cal. Type” to “Manual”.
3. Set “Cal. Mode” to “Zero” (to indicate that the measurement sample should be drawn from the Calibration port).
4. Allow the instrument to stabilise for 15 minutes.
5. Select the “Zero Calibration” field and enter 0.0 (the gas concentration).

Sample Port

1. Ensure a suitable zero source is connected to the **Sample port** on the back panel of analyser (refer to Section 0).
2. Set “Cal. Type” to “Manual”.

3. Set “Cal. Mode” to “Measure” (to indicate that the measurement sample should be drawn from the Sample port).
4. Let the instrument stabilize for 15 minutes.
5. Select the “Zero Calibration” field and enter 0.0(the gas concentration).

Span Calibration

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. Ecotech recommends that 80% of full scale should be sufficient for calibrations in ambient monitoring situations (400 ppb). Follow the instructions below:

Calibration Port

1. Ensure a suitable span gas source is connected to the calibration port on the back panel of analyser (refer to Section 0).
2. Set the span source to a known concentration (80% full scale recommended).
3. Enter the **Main menu → Calibration menu**.
4. Set “Cal. Mode” to “Span”.
5. Let the instrument stabilise (15 minutes).
6. Enter the **quick menu** and select “Span Calibrate”.
   (Also accessible through: **Main Menu→Calibration Menu→**”Span Calibrate”).
7. A box will appear with editable numbers. Select the concentration being delivered to the instrument.
8. The instrument will perform a span calibration. When finished the instrument will return to normal activities.

Sample Port

Ensure a suitable span gas source is connected to the sample port on the back panel of analyser (refer to Section 0).

1. Set the span source to a known concentration.
2. Let the instrument stabilise (15 minutes).
3. Enter the **quick menu** and select “Span Calibrate”.
4. A box will appear with editable numbers. Select the concentration being delivered to the instrument.
5. The instrument will perform span calibration. When finished the instrument will return to normal activities.

Multipoint Calibration Check

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 the concentration readings over the range of the multipoint calibration. The instrument gain should not be adjusted to each individual point.

1. Ensure a suitable span source is connected to the instrument from a gas calibrator (Ecotech recommends the GasCal-1100 with GPT) through the calibration port.
2. Record analyser instrument gains before performing calibration (refer to Section 0).
3. Perform a zero check using zero air as described in section 0.
4. Perform a span calibration as described in section 0.
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 1st concentration on the gas calibrator to 400ppb, allow instrument to sample for 15 minutes, record the measurement.

b. Set the 2nd concentration on the gas calibrator to 300ppb, allow instrument to sample for 15 minutes, record the measurement.

c. Set the 3rd concentration on the gas calibrator to 200ppb, allow instrument to sample for 15 minutes, record the measurement.

d. Set the 4th concentration on the gas calibrator to 100ppb, allow instrument to sample for 15 minutes, record the measurement.

e. Set the 5th point at a concentration of 0ppm (zero air); allow the instrument to sample for 15 minutes and record the measurement.

6. The linearity and correlation can be calculated for each point manually or all points calculated within an excel spread sheet. Both options are detailed below.

Manual Calculations

Record the concentration measurement at each point and determine the percentage difference between the instrument response and the supplied concentration using the following equation:

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

Equation 3 - Instrument Accuracy

If the difference between values is less than 1% of full scale then the instrument is within specifications. If not, a leak check and/or service are required (refer to Section 0).

Microsoft Excel

All the data can be placed in an Excel spread sheet in columns next to the supplied concentration.

1. 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.
2. The linear regression equation y = mx + b will be displayed as:

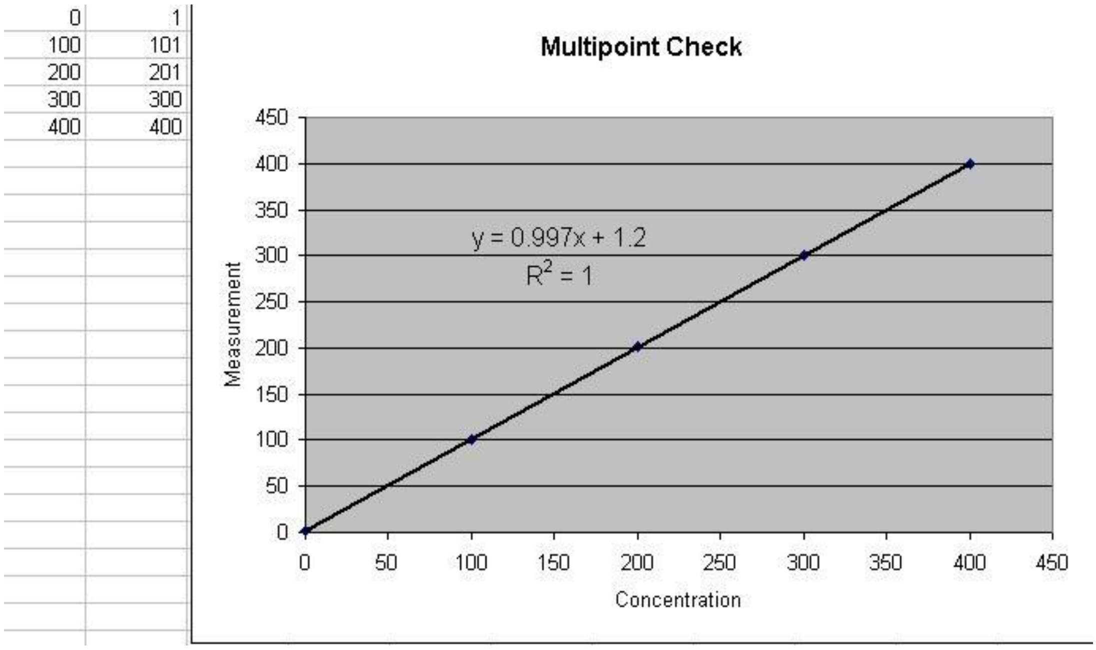


Figure 27 – Excel graph of Multipoint Calibration

3. Accept the calibration if the following are found:
   a. The gradient (m) falls between 0.98 and 1.02.
   b. The intercept (b) lies between -0.3 and +0.3.
   c. The correlation (R2) is greater than 0.9995.
4. Reject the calibration if the above criteria are not met; if these measurements do not match step 7. If the calibration fails, perform a leak check (refer to Section 0), check zero air scrubbers or check troubleshoot guide for possible errors (refer to Section 0).

Converter Efficiency

The efficiency of the converter can affect NO_X readings and therefore the converter efficiency must be measured to ensure the efficiency is at an adequate level (96% or higher). It is also required to correct the measurements to remove losses by converter inefficiency.
To measure and correct converter efficiency the following steps should be followed:

1. Enter **Main Menu → Calibration Menu** and set the converter efficiency field to “100%”. Return to **main menu.**
2. Supply the instrument with 90% full scale NO span gas.
3. Allow the instrument to stabilize then record the NO reading as [NO]ORIG and NO2 reading as [NO2]ORIG.
4. Turn on the O_3 generator in the Gas Phase Titration system and produce sufficient O_3 to generate 90% 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 stabilise then record the NO reading as $[NO]_{FINAL}$ and NO_2 as $[NO_2]_{FINAL}$

6. Calculate the converter efficiency from the following equation:

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

Equation 4 - Calculation for converter efficiency

7. If the 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.

Precision Check

A precision check is a Level 2 calibration. This means that the instrument has a known span gas 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. Refer to your regional standards for appropriate pass/fail criteria.

Initial Pressure Sensor Check

This check allows the user to verify that all three pressure sensors are adequately calibrated.

1. Disconnect the exhaust and sample lines on the rear of the instrument.
2. Wait for 10-15 minutes.
3. Enter **Main Menu→Analyser State→Pressure & Flow**.

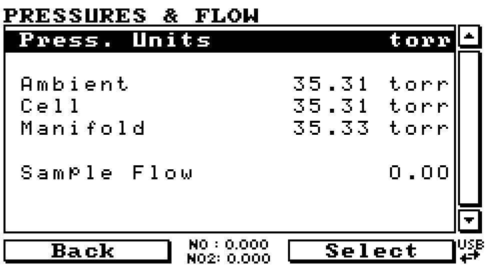


Figure 28 – Pressure sensor check

4. If the pressure sensor readings differ by more than ±3 torr (± 0.4 kPa), perform a pressure calibration (refer to Section 0).
5. Reconnect exhaust and sample lines.

Pressure Calibration

The pressure calibration involves a two point calibration. One point is under vacuum and another point is 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 full pressure calibration.

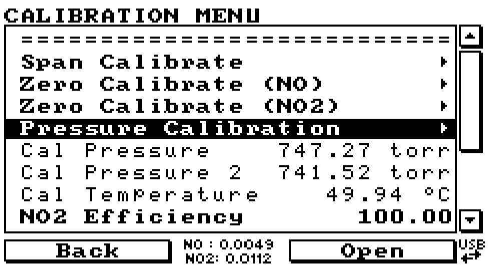


Figure 29 – Calibration Menu, pressure calibration

Vacuum

1. Enter **Calibration menu** → Pressure Calibration and open

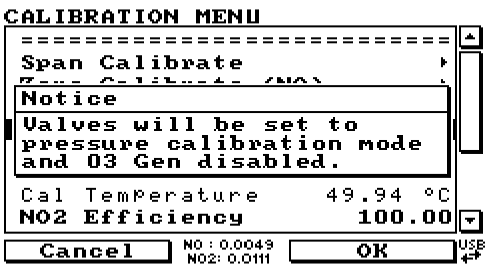


Figure 30 – Vacuum calibration, ozone generator offline warning

Note: This action will disable the ozone generator and place the valve sequence on hold.

2. Select Vacuum Set pt. → OK

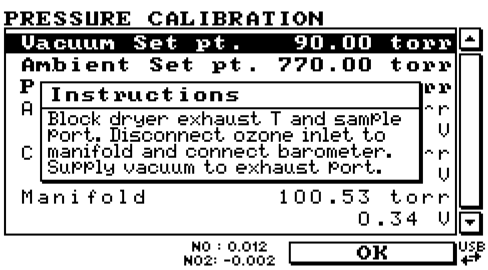


Figure 31 – Vacuum calibration, on-screen instructions

3. Open instrument (refer to Section 0)
4. Remove the tubing connecting the dryer to the exhaust line and block the exhaust line T-piece (see Figure 32 - Blocking exhaust T-piece, page 71).

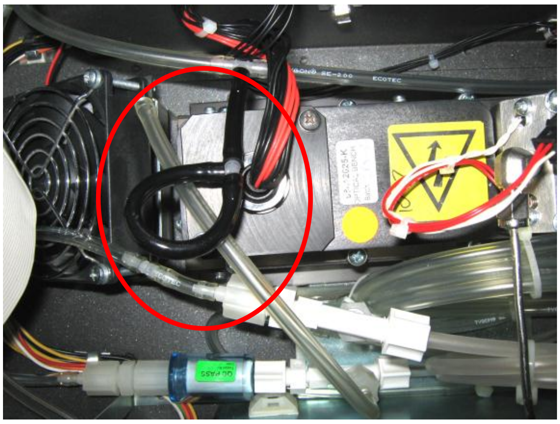


Figure 32 - Blocking exhaust T-piece

5. Disconnect the tubing connecting the valve manifold to the ozone generator and connect the barometer on the valve manifold ozone inlet port (see Figure 33).

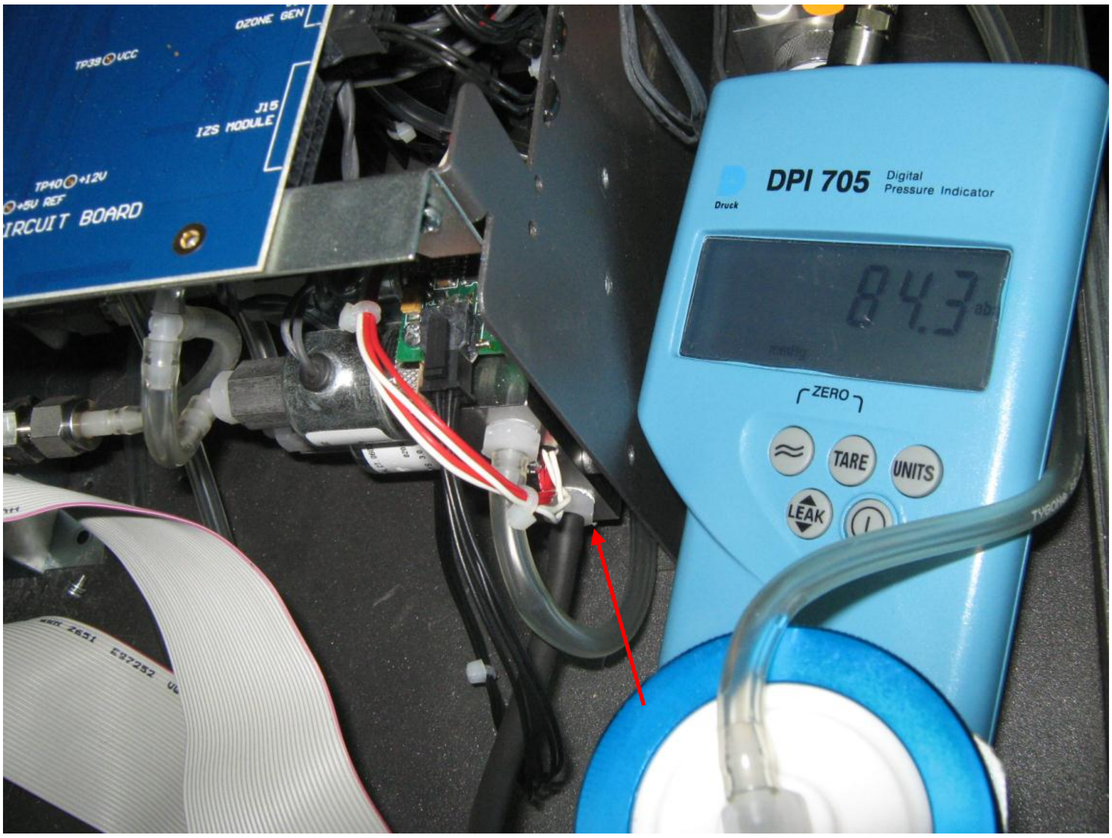


Figure 33 - Position of Barometer placement (valve manifold)

6. Connect the vacuum source to the exhaust port of analyser. Block the sample port and switch the vacuum source on (refer to Figure 34).

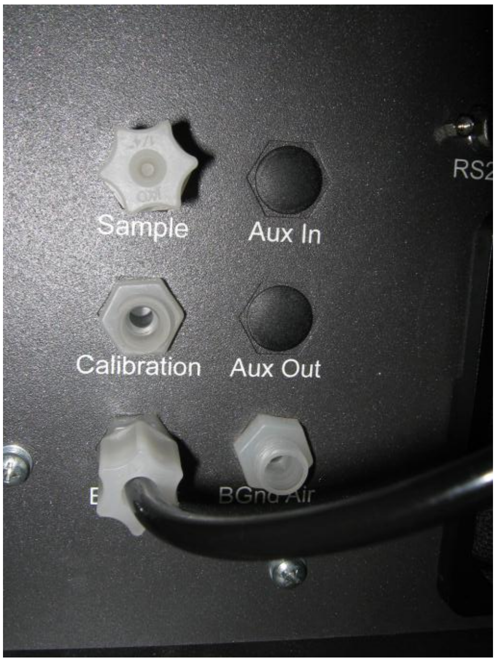


Figure 34 - Rear analyser ports

7. Enter the value displayed on the external pressure sensor ensuring that the units used are the same as selected in the instrument. The screen will display three voltages. The first is for the ambient pressure sensor. The second is for the cell pressure sensor and the third is for the pressure sensor in the valve manifold.
8. Ensure that the pressure is stable (Voltage stable), before pressing the “Accept” button to calibrate pressure sensors.

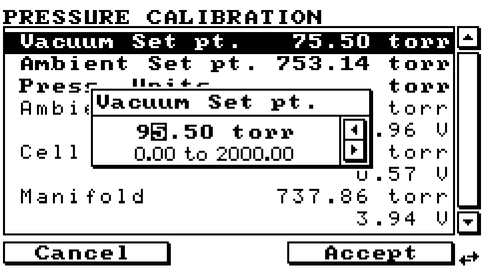


Figure 35 – Vacuum calibration, entering vacuum set point

Note: Only the cell and manifold sensors will be calibrated as they will be exposed to the vacuum.

9. Disconnect external vacuum, sample port blocker and the exhaust line tee blocker.

Figure 36 – Vacuum calibration, on-screen instructions

10. Ensure that the pressure is stable (voltage stable).
11. Press the “Accept” button to calibrate the pressure sensors.

Ambient

1. Ensure that any vacuum source connected to the exhaust port of the analyser has been switched off and disconnected. Also disconnect any tubing connected to the sample port.
2. Enter **Calibration Menu** → **Pressure Calibration** →Ambient Set pt. and edit.

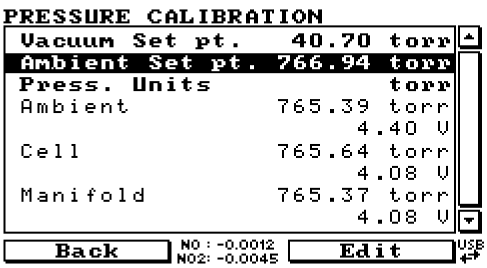


Figure 37 – Ambient pressure calibration screen

3. Edit the Ambient Set pt. value with the current ambient pressure. Ensure you are using the same pressure units that are shown on screen.

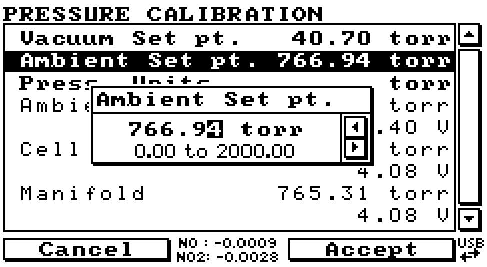


Figure 38 – Setting ambient set pressure

4. Press the “Accept” button to calibrate the pressure sensors.

Note: All three sensors should now be displaying the current ambient pressure.

5. Reconnect all pneumatic connections back to the normal sample positions and remove the barometer.

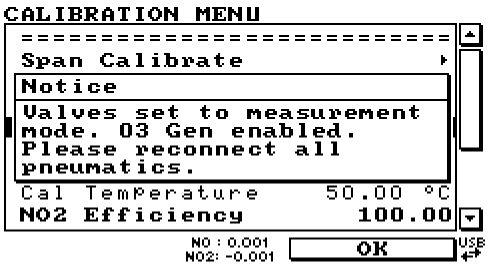


Figure 39 – Return to normal mode notice

Service

Note: The Serinus 40's internal ozone destroyer removes near 100% of ozone in exhaust air (<20ppb remains). An additional optional charcoal scrubber can be attached to the exhaust to capture NO_2 and low levels of ozone.

Pneumatic Diagram

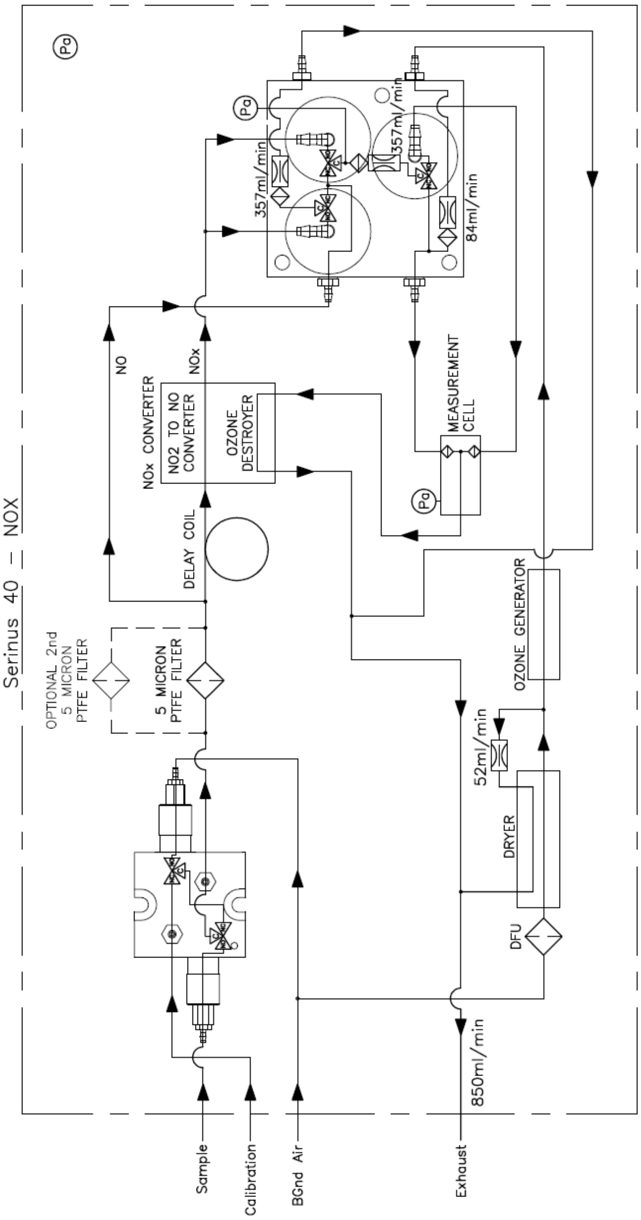


Figure 40 - Pneumatic diagram

Maintenance Tools

To perform general maintenance on the Serinus 40 the user may require the following equipment:

- Digital multimeter (DMM)
- Computer or remote data terminal and connection cable for RS232 or USB communication
- Pressure transducer (absolute) and connection tubing
- Flow meter (1 slpm nominal)
- Minifit extraction tool

- Orifice removal tool
- Assortment of 1/4” and 1/8” tubing and fittings
- Zero air source
- Span gas source
- Leak tester
- Isopropyl alcohol
- Lint free tissues, Latex gloves, Cotton buds

Recommended Maintenance Schedule

Table 4 - Maintenance schedule

Interval *	Task performed	Section	Page
Weekly	Check inlet particulate filter, replace if full/dirty	0	76
	Check sample inlet system for moisture or foreign materials. Clean if necessary		
	Perform precision check	0	69
Monthly	Check fan filter, clean if necessary	0	77
	Perform span calibration	0	66
6 Monthly	Check the Converter efficiency	0	68
	Perform multi-point calibration check	0	66
	Check date and time is correct	0	38
Yearly	Replace DFU filter	0	87
	Replace sintered filter and orifice (only if necessary)		
	Perform a pressure check	0	82
2 years	Clean Reaction Cell	0	81

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

Maintenance Procedures

Note: If an external charcoal scrubber is used with the Serinus 40, the exhaust must be maintained for 15 minutes after powering off the instrument. This is necessary to purge all of the ozone preventing its build up and combustion with charcoal in the exhaust scrubber.

Note: When powering off the Serinus 40, vacuum to the exhaust should be maintained for 15 minutes in order to prevent ozone build up in the charcoal scrubber.

Particulate Filter Replacement

Contamination of the filter can result in degraded performance of the analyser, including slow response time, erroneous readings, temperature drift, and various other problems.

1. Disconnect the external pump.

2. Slide open the lid of the analyser to access the particulate filter (located in front right hand corner).
3. Unscrew the filter cap (bright blue) by turning it counter-clockwise.
4. Remove the filter plunger from the casing, place finger on tubing connector and pull to the side (refer to Figure 41).

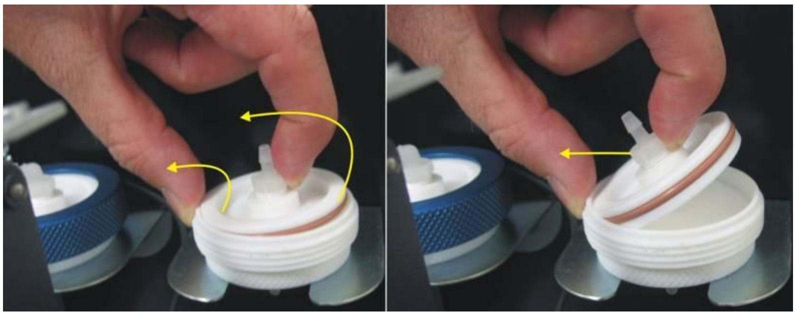


Figure 41 - Removing plunger

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 leak check (refer to Section 0).

Clean Fan Filter

The fan filter is located on the rear of the analyser. If this filter becomes contaminated with dust and dirt it may affect the cooling capacity of the analyser

1. Disconnect the fan power cable.
2. Remove outer filter casing and filter (refer to Figure 42).
3. Clean filter by blowing with compressed air (if available) or shaking vigorously.
4. Replace filter and filter casing.

Figure 42 - Removing the fan filter

DFU Replacement

1. Turn the analyser off and unplug from the power.
2. Remove the Kynar nut from the end of the DFU by turning it anti-clockwise (looking from the DFU side).
3. Replace the DFU and ensure that the flow is in the correct direction (arrow should point towards the Kynar nut).
4. Tighten the Kynar nut clockwise.

Figure 43 - DFU filter

Quick Leak Test

This procedure is designed to determine if the instrument pneumatics have a leak. This procedure is used for diagnostics purposes during many troubleshooting activities. If the instrument passes this check then no further leak checks are required, if it fails, a full leak check will be required.

1. Enter **Main Menu** → **Service Menu** → **Diagnostics** → **Valve menu** and set valve sequencing to “Disabled”. Then close all the valves in that menu.
2. Plug the “Sample port”, “Calibration port” and the “Bgnd Air port” (see Figure 44).

Figure 44 - Plugged sample, background, and calibration ports

3. Enter the **Main Menu** → **Analyser State** → **Status Menu** → **Pressures & Flow Menu** and compare the cell and the manifold pressures.
4. Allow 2 minutes for the pressures to stabilise.

5. If the two pressures are within 10% of each other then the leak check has passed.
6. If the pressure readings (cell and manifold) are more than 10% different, perform a pressure calibration (refer to Section 0), after this is completed repeat the quick leak check, if this fails again then perform a manual leak check (refer to Section 0).
7. Enter **Main Menu → Service Menu → Diagnostics → Valve menu** and set valve. Then set span/zero select open. Follow steps 3 and 4 if the two pressures (cell and manifold) are within 10% of each other the leak check has passed.
8. Enter **Main Menu → Service Menu → Diagnostics → Valve menu** and set valve. Then set span/zero select open and cal port select Open, follow steps 3 and 4 if the two pressures (cell and manifold) are within 10% of each other the leak check has passed.
9. If any of the tests failed or if you suspect a leak then perform a manual leak check.

Full Leak Check

If a leak is suspected a more intensive leak check can be performed.

Equipment Required

- Source of vacuum (pump)
- Vacuum gauge
- Shut off valve
- Swagelok ¼” blocker nut

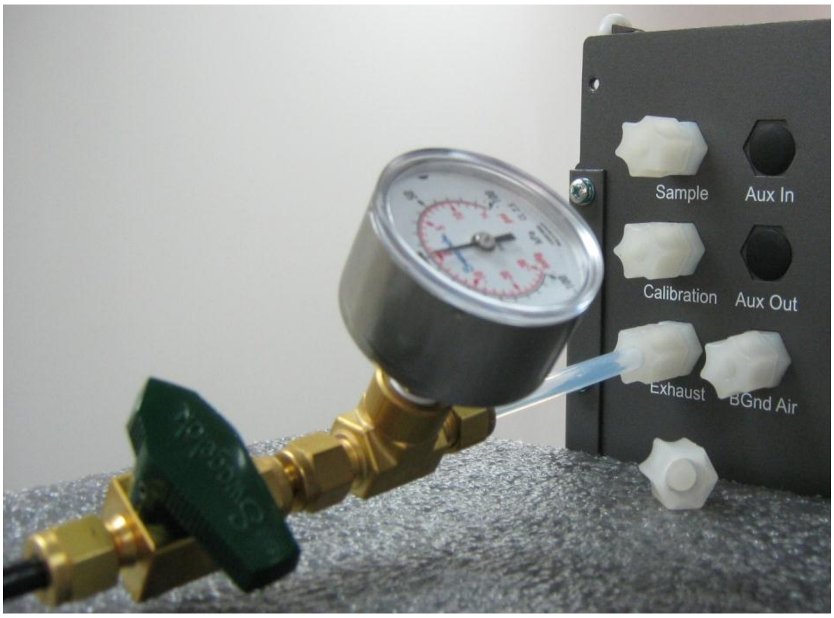


Figure 45 – Pressure gauge on exhaust

Leak Check Procedure

1. Connect a shut off valve to the exhaust port of the analyser.
2. Connect a pump to the shut off valve ensuring the shut off valve is in the open position, turn on the pump.
3. Block the analyser’s sample calibration and BGnd air ports with a swagelok ¼” blocker nuts.

4. Switch on the analyser, navigate from the **Main Menu → Service Menu → Diagnostics → Valve menu**. Switch off the valve sequencing and close all valves.
5. Close the shut off valve and record the vacuum. Wait for 3 minutes and then observe the gauge on the leak check jig. It should not drop more then -5kpa. If it has then a leak is present within the sample cycle of the instrument.
6. Enter **Main Menu → Service Menu → Diagnostics → Valve menu** and set valve. Then set Span/Zero Select Open.
7. Turn on the pump, switch the shut off valve to the open position and allow the pump to evacuate the pneumatics.

   Switch the shut off valve to the closed position and turn off pump. Record the vacuum indicated on the leak checking device. Wait 3 minutes observe the gauge on the leak check device. It should not drop more then -5kpa. If it does then a leak is present within the zero cycle of the instrument.
8. Enter **Main Menu → Service Menu → Diagnostics → Valve Menu** and set valve. Then set Span/Zero Select Open and Cal Port Select Open
9. Turn on the pump, switch the shut off valve to the open position and allow the pump to evacuate the pneumatics.
10. Switch the shut off valve to the closed position and turn off pump. Record the vacuum indicated on the leak checking device. Wait 3 minutes observe the gauge on the leak check device it should not drop more then -5kpa, if it has then a leak is present within the span calibration cycle of the instrument.
11. If the instrument did not leak then skip to step number 15.
12. Inspect the instrument's plumbing looking for obvious damage. Check the condition of fittings, sample filter housing, O rings both in the filter assembly and in the cell assembly.
13. When the location of the leak has been determined repair and then rerun the leak check procedure.
14. Inspect the tubing again ensuring that the tubing is cleanly connected to the fittings and that the internal Teflon lining has not been kinked or crumpled.
15. Remove the leak check jig and swagelok blocking nuts.
16. Re-enable valve sequencing from the **Valve Menu**.

Replacing the PMT Desiccant Pack.

The PMT housing contains two desiccant packs to prevent condensation on the cooled PMT housing. If the desiccant expires it will result in corrosion and premature cooler failure. It is recommended that the desiccant bags be changed at least annually. If moisture is detected inside the housing or the desiccant packs are saturated the interval should be reduced. To change the desiccant packs follow the instructions below.

CAUTION

Because the PMT is extremely sensitive to light, it is essential that before opening the PMT assembly to make sure that the analyser is switched off. Once the analyser is switched off it is very important to cover the PMT at all times so that no direct light reaches its window.

1. Turn the analyser off and disconnect power.

2. Using an offset Phillips head screwdriver, remove the desiccant pack access cap from the PMT housing.

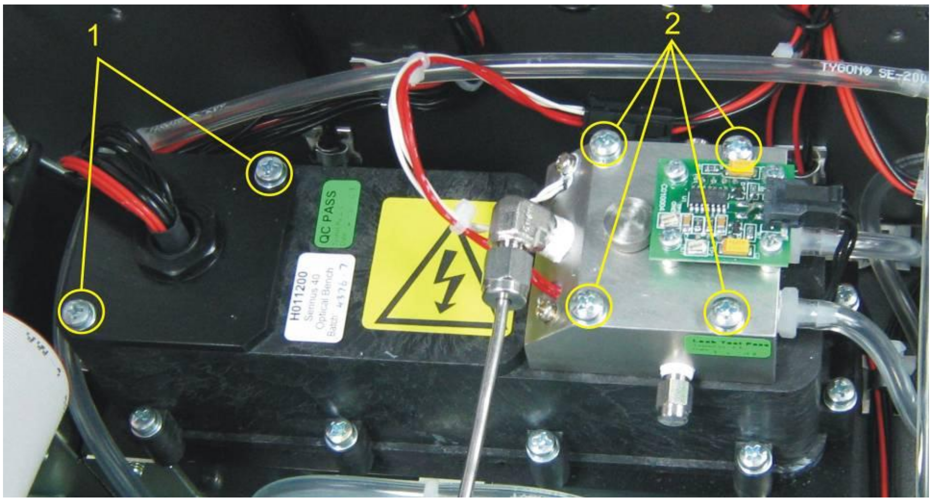


Figure 46 - Removing the reaction cell or desiccant pack

3. Remove the old desiccant packs and replace 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 or the desiccant pack is saturated, the desiccant pack should be replaced more frequently.
5. Reinstall the desiccant cap by gently twisting and pressing the cap back into the PMT housing. It may help to apply a small amount of lubricant to the O-ring on the desiccant cap. Secure with two screws.

CAUTION

Do not attempt to use the fastening scrws to push the desiccant cap in place in the the PMT housing. This will damage the PMT housing.

6. Reconnect power and restart the analyser.

Cleaning the 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 analyser and increase the gain required to take readings. 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.

CAUTION

Because the PMT is extremely sensitive to light, it is essential that before opening the PMT assembly to make sure that the analyser is switched off. Once the analyser is switched off it is very important to cover the PMT at all times so that no direct light reaches its window.

1. Turn of the analyser 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 Figure 46).

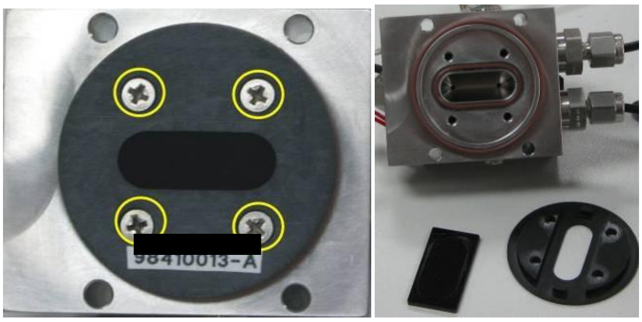


Figure 47 - Optical filter removal and cleaning

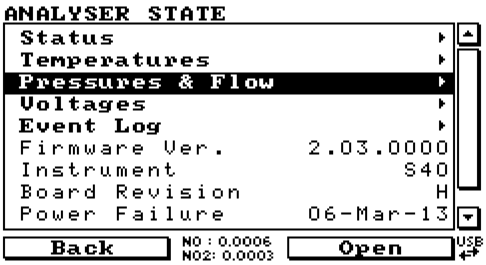
3. Turn the reaction cell upside down and remove the four screws fastening the optical filter from the cell.
4. Clean the filter and the inside of the cell with high purity isopropyl alcohol.
5. Ensure that all traces of the isopropyl alcohol have been removed by either blowing it out with clean oil free compressed air or by gently heating the assembly.
6. Reassemble the reaction cell in reverse order to the steps above..
7. Recalibrate the analyser.

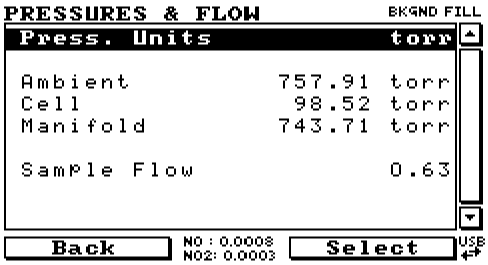
Clean Pneumatics

The simplest method is to replace the tubing. The valve manifold will require disassembling and cleaning. Ideally the vales and manifold should be cleaned in a sonic bath with soppy water. Once clean, rinse with distilled water and dry before reassembling. A leak test should be performed once the analyser is ready for service (refer to Section **Fehler! Verweisquelle konnte nicht gefunden werden.**).
If new tubing is not available then the pneumatic lines (sample and exhaust) may be cleaned by removing and washing with a methanol cotton swab and dried by blowing with zero air or dry nitrogen. Do not clean the ozone generator or NO2 converter.

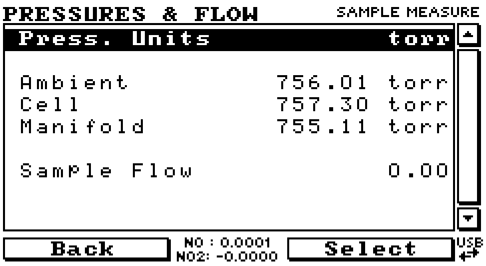
Pressure Sensor Check

Pressure checks are needed to ensure that the pressure sensor is accurately measuring pressure inside the instrument
During normal operation ensure that the pressure and **flow menu** indicate the following parameters. Ambient should display the current ambient pressure at site. Cell should indicate current cell pressure depending on the pump condition and location. A value of between 50 torr and 200 torr is recommended. The manifold pressure is normally about 20 torr below ambient.
To navigate to the pressure and flow menu, Enter **Main Menu → Analyser State → Pressures and Flow**.





1. A simple way of checking the pressure sensors response is to disconnect the exhaust and sample tubing from the back of the analyser. After 2-5minutes observe the pressure readings: ambient, cell and manifold. Ensure that they are reading the same ± 3 torr (± 0.4 kPa).



2. If the readings are outside this level then perform a pressure calibration (refer to Section 0).
3. If the calibration fails then the instrument may have a hardware fault. The cell pressure PCA and the manifold pressure PCA have test points. To determine if the pressure sensor is faulty simply measure the voltage on the test points show in the photos. The voltage measured across the test point is proportional to the pressure measured by the sensor so if the sensor is exposed to ambient pressure at sea level then the voltage will be around 4 volts but if the sensor is under vacuum then the voltage will be low for example 0.5 volts. If the test point measures zero of negative voltage then the assembly is most likely faulty and will need to be replaced.

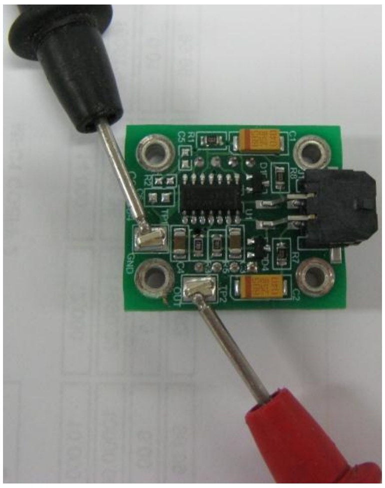


Figure 48 – Test point location

Figure 49 – Typical test point reading of cell pressure with vacuum connected to exhaust port

Figure 50 – Typical test point reading of manifold pressure sensor

Battery Replacement

The replaceable battery (BT1) on the main controller board may need to be replaced. If the clock resets or does not increment when the power is off, then the battery is going flat. The battery should be replaced with the correct type of battery, a 3V Lithium CR2025 type should be used and installed correctly as follows:

1. Turn off the Instrument, open the lid and remove the 2 screws holding down the main controller PCB.
2. Lift the PCB up to its open position. The battery (BT1) is located toward the front of the PCB
3. Using a small flat screwdriver, lift the metallic clip holding the battery whilst sliding the old battery out.
4. Now place the new battery in with the positive (+) side facing up.
5. Close the main PCB and return the screws. Close the lid again.
6. Turn on the instrument and set the clock time and date in the "**General Settings**" menu (refer to Section 0).

Ozone Generator Maintenance

Ozone production in the Serinus 40 is achieved via a corona discharge method. Ambient air is drawn through a DFU (disposable filter unit), a Nafion dryer and then into the ozone generator and high levels (≈6,000ppm) of ozone are produced. This reactive gas can deteriorate the Viton O-rings over time that are found in the ozone generator assembly (pre ID11-1040) part number H011107.

CAUTION

Risk of electric shock. Do not power assembly during maintenance procedures.

The Viton O-rings require replacement at least every 12 months. More recent ozone generators use Teflon seals which virtually eliminates the need for regular maintenance. Ecotech has used Teflon seals on all instruments with serial numbers after ID 11-0140. If your instrument has an ID number before this, follow the procedure outlined below to change the O-rings.

O ring Replacement Procedure for ozone generator (pre ID 11-0140)

1. To remove the ozone generator assembly from the instrument chassis. Firstly undo the two captive screw found on the top of ozone generator assembly.

Figure 51 – Ozone generator assembly.

2. Disconnect the electrical plug and the two tube connections from the assembly. Remove the four screws on the side. (Remove the coil and ozone generator cell assembly after ensuring the pneumatic and electrical connections are disconnected.

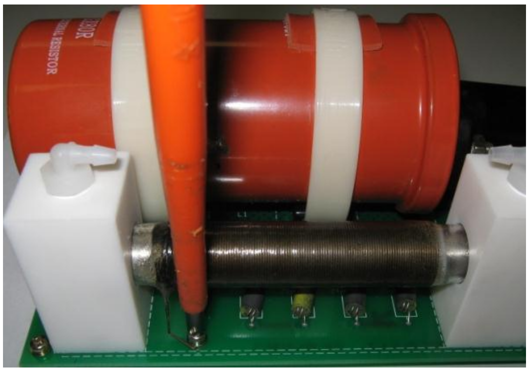


Figure 52 – Ozone generator cell assembly

Figure 53 – Removing ozone generator cell assembly

3. Remove the ozone producing cell assembly by first unscrewing the the spring conductor connection and then removing the screws that secure the Teflon blocks at each end of the assembly.

CAUTION

Take care not to knock glass tube.

4. Disassemble the glass and shaft from the Teflon blocks gently separating them by hand.
5. Remove the four O-rings. During services it is recommended that the stainless steel shaft conductor is cleaned and polished with alcohol solution, if heavily oxidized, polish with steel wool or fine grade wet and dry sandpaper. Ensure any finger marks are wiped clean.

Figure 54 – Disassembled ozone generator cell assembly

6. Fit the new Viton O-rings (refer to Figure 55) O010019 and O010020.

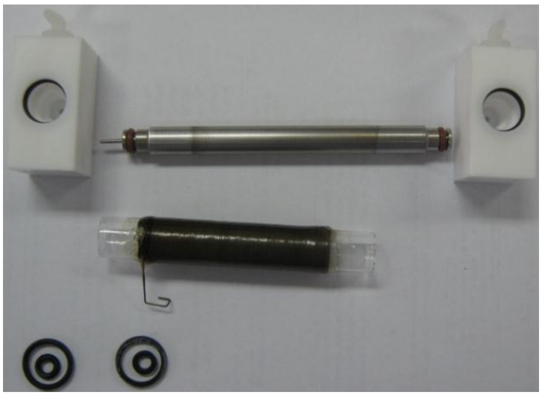


Figure 55 – Replacing Viton O-rings

7. Reassemble the ozone generator assembly. A complete assembly leak check should be performed before re-installing the unit in the analyser.

Parts List

Below is a list of the replaceable parts of the Serinus 40. Some of these parts will not need replacing and others are consumables for preventative maintenance. See below for information on yearly consumable kits available from Ecotech.

Table 5 -Spare Parts List

Part Description	**Part Number**
Tube, side-on, photomultiplier	H011203
Heater and thermistor assembly	C020073
LCD and interface assembly	H010130
PCA, controller (Programmed with ID number)	E020220
Power supply, Serinus	P010003
Filter, optical, reaction cell	H011205
Heater/thermocouple assembly NOx converter	C020072
Heater/thermistor assembly (reaction cell, manifold)	C020073
Ozone generator and housing assembly	H011107
Retrofit/refurbishment Kit, Ozone generator (confirm with Ecotech which version you have)	H011134
Sample valve manifold assembly	H010013-01
CABLE, PMT POWER SUPPLY NOX, GAS ANALYZER	C020050-01
Cooler, thermister assembly	C020088
Thermistor assembly kit	H011211-04
Dryer assembly, Permapure	H011106
Extraction tool, orifice and sintered filter with O-ring groove	H010046
PCA pressure sensor assembly	C010004
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

Part Description	Part Number
Plug Test Lamp	H010026
Test Lamp	E020103
Serinus 40 User Manual	M010028
Sintered filter, 5 micron, consumable	F010004
Gasket Pressure Sensor	H010037

Table 6 – Serinus Maintenance Kit

Serinus 40 Maintenance Kit*	**E020203-01**
Silicone heat sink compound	C050013
Dessicant 5 gram pack qty 2	C050014
Filter, Sintered qty 1	F010004
Filter DFU 23 micron qty 1	F010005
Nylon washer-spacer heat shield qty 2	F050040
Washer NEO, .174 x .38 x .015 qty 2	F050041
Spring compression, 0.24 DIA qty 1	H010040
Filter sintered qty 2	H010047-01
Filter sintered qty 3	H010053
O- ring 0.364ID X 0.070W qty 7	O010010
O-ring, orifice and filter qty 4	O010012
O-ring 5/32ID X 1/16W, Viton qty 5	O010013
O- ring 1 11/16ID X 3/32W Viton qty 2	O010014
O- ring 1/4ID X 1/16W, Viton qty 7	O010015
O-ring, reaction cell-optical filter qty 8	O010016
O-ring, reaction cell housing qty 1	O010017
O-ring, Opt bench assembly qty 1	O010018
O-ring 3/16ID X 3/32W, EP qty 2	O010019
O-ring 5/8ID X 3/32W, EP qty 2	O010020
O-ring, test lug qty 1	O010021
O-ring, Desiccant access cap qty 1	O010022
O-ring BS015, Viton qty 7	O010023
O-ring BS006, PTFE qty 1	O010032
Tubing, tygon, ¼ x 1/8 clear 3 feet	T010011

*The above maintenance kit is suitable only for instruments with serial number 11-0001 and beyond. Analysers with serial numbers lower than 11-0000, require kit E020203 – contact Ecotech for more details.

Table 7 – Other Consumables – Not listed in Maintenance Kit

Other Consumables (not listed in maintenance kit)	
Filter paper Teflon 47MM pack of 50	F010006-01
Filter paper Teflon 47MM pack of 100	F010006
NO_2 to NO converter assembly,	H011105-40
Orifice, 4 mil	H010043-02
Orifice 8 mil (2 required)	H010043-06
Tube/Spring assembly, O_3 Generator	H011120-01
Orifice 3 mil	H010043-01
External pump repair kit (suite 607 pump)	P031001

Bootloader

The Serinus bootloader is the initial set of operations that the instruments microprocessor performs when first powered up. (Similar to the BIOS found in a personal computer). This occurs every time the instrument is powered up or during instrument resets. Once the instrument boots up it will automatically load the instruments firmware. A service technician may need to enter the state between the Bootloader and the firmware load.
To do this power up the instrument and immediately press the plus key multiple times until the following screen appears.

```
** Ecotech Serinus Analyser **
V2.1 Bootloader
Press '1' to enter Bootloader
```

If the analyser displays the normal start up screen then the power will need to be toggled and another attempt will need to be made to enter the bootloader screen. Once successful Press 1 to enter the **Bootloader menu**.

Display Help Screen

Once in the Bootloader screen it is possible to redisplay the help screen by pressing 1 on the key pad.

Communications Port Test

This test is very useful for fault finding communication issues. It allows a communication test to be carried out independent to any user settings or firmware revisions.
This command forces the following communication ports to output a string of characters: serial port RS232 #1, USB rear, and ethernet port. The default baud rate is 38400 for the RS232 serial port. To initiate the test press the number 2 key from the bootloader screen.

Updating Firmware

It is important for optimal performance of the Serinus analyser that the latest firmware is loaded onto the analyser. The latest firmware can be obtained by visiting Ecotech's website **http://www.ecotech.com/downloads/firmware**
or by emailing Ecotech at service@ecotech.com.au **or** intsupport@ecotech.com
To update the firmware from a USB memory stick, use this procedure;

USB Memory Stick Update

1. Turn instrument off.

2. Place USB memory stick with new firmware (ensure that firmware is placed in a folder called FIRMWARE) in the front panel USB port.
3. Enter the Bootlader (Refer to Section 0)
4. Select option 3, (Upgrade from USB memory stick) press 3 on keypad.
5. Wait till upgrade has completed
6. Press 9 to start the analyser with new firmware.

Erase All Settings

This command is only required if the instruments firmware has become unstable due to corruption. To execute command enter into **bootloader menu** and select key 4.

Start Analyser

The start analyser command will simply initiate a firmware load by pressing key 9 from the **Bootloader Menu**. It is generally used after a firmware upgrade.

This page is intentionally blank.

Troubleshooting

Table 8 - Troubleshoot list

Error Message/ Problem	Cause	Solution
Zero Flow	Multiple	Troubleshoot 0
Reset Detection		Upgrade firmware
12 Voltage supply failure	Power supply has failed	Replace power supply
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 0.6 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.

Error Message/ Problem	**Cause**	**Solution**
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. 3. Faulty optical bench or ozone generator
Zero drift	Leak	Perform leak test (refer to Section 0)
Converter temp Failure	Multiple	See Troubleshoot 0
Flow block temp failure	Multiple	See Troubleshoot 00
Reaction cell temp failure	Multiple	See Troubleshoot 0

Zero Flow

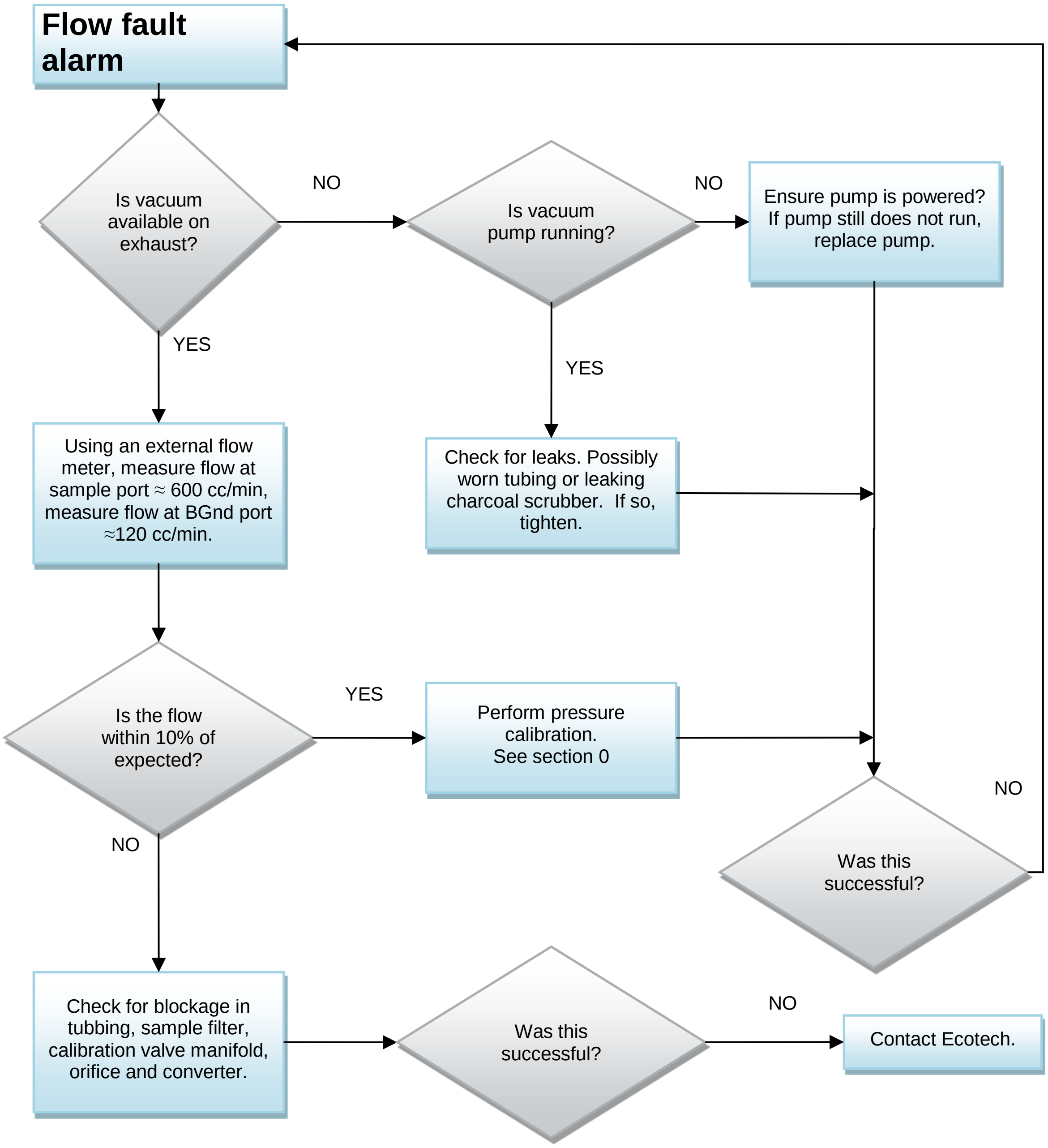


Figure 57 – Zero flow fault troubleshooting flow chart

Noisy Readings

Table 9 - Noisy readings troubleshoot

Cause	Solution
Gain too high	1. Leak check (repair any leaks)
	2. Optical filter in reaction cell contaminated requires cleaning.
	3. PMT voltage too low less than 640V
	4. BGnd port flow too high >130cc/min. Service instrument.
Cell pressure too high (>280 torr)	1. Leak check (repair any leaks)
	2. Replace external pump.
	3. BGnd port flow too high >130cc/min. Service instrument.
	4. Recalibrate pressure sensors.
PMT temperature too high (>15ºC)	1. Check optical bench heat sink fan is operating. 2. Check PMT cooler is operational, and correct amount of thermal paste is applied.
Unstable ozone generator	Substitute ozone generator with known working generator. If instrument now works replace ozone generator.

Converter Temperature Failure

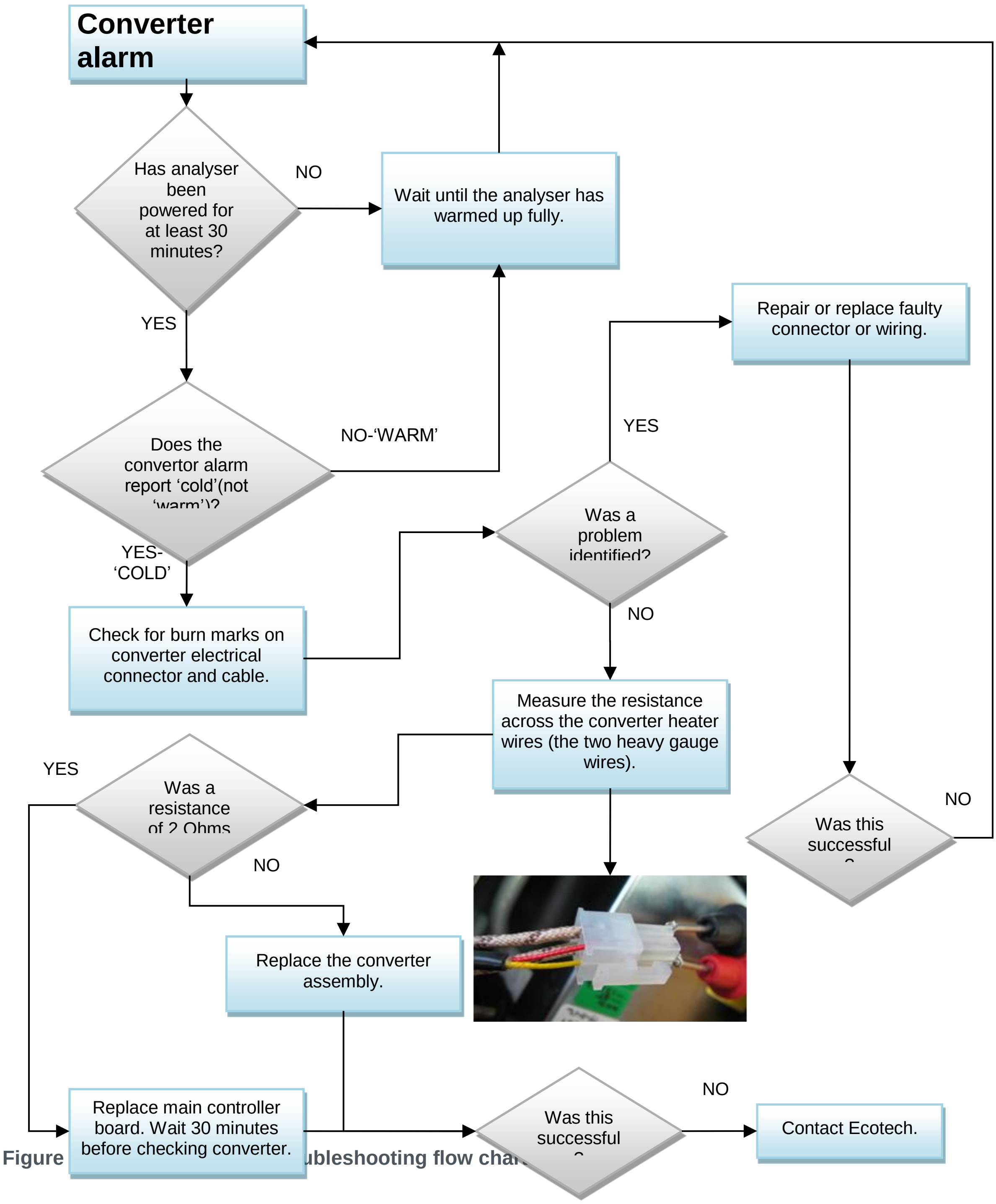


Figure … ubleshooting flow char…

Flow Block Temperature Failure

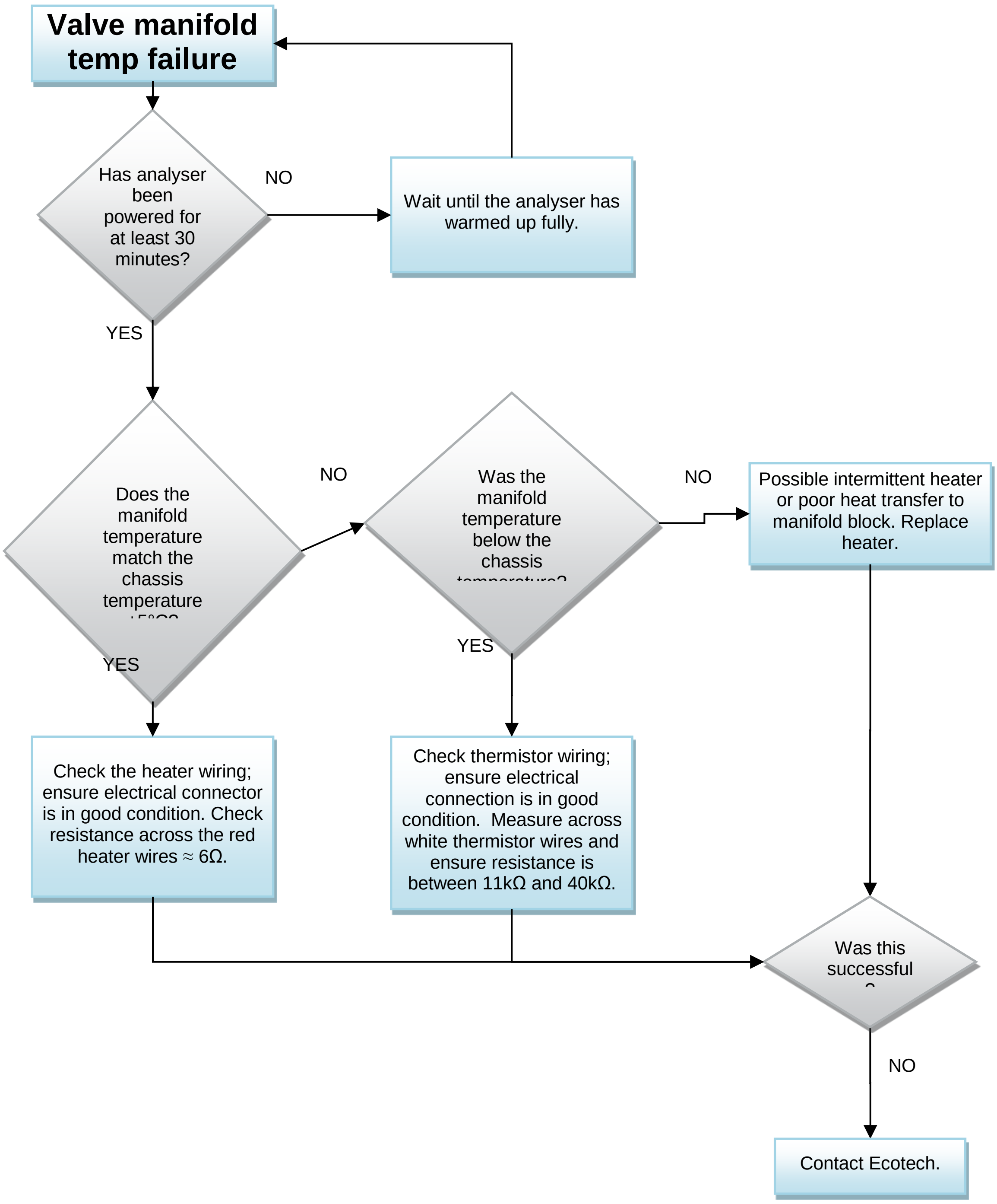


Figure 60 – Valve manifold temperature alarm troubleshooting flowchart

Reaction Cell Temperature Failure

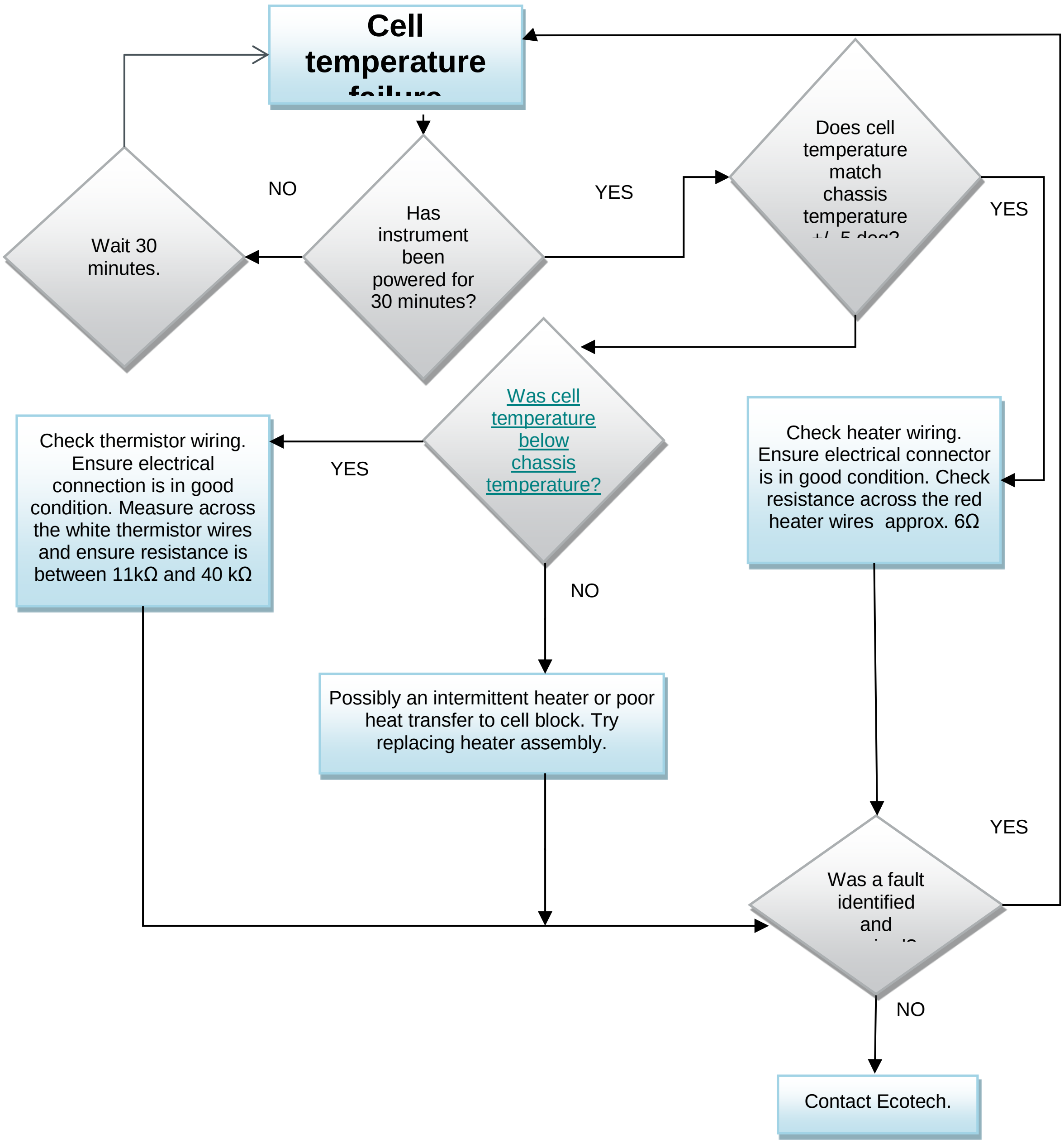


Figure 61 – Reaction cell temperature failure troubleshooting flow chart.

Optional Extras

Dual Sample Filter PN E020100

The dual filter is designed with two sample filters plumbed in parallel with a split line. This formation allows sample flow not to be affected, yet reduces the loading on each filter, and therefore the frequency with which they will need to be changed.
The dual filter option is shown in the pneumatic diagram (red dashed line) and requires no operational changes to the instrument.

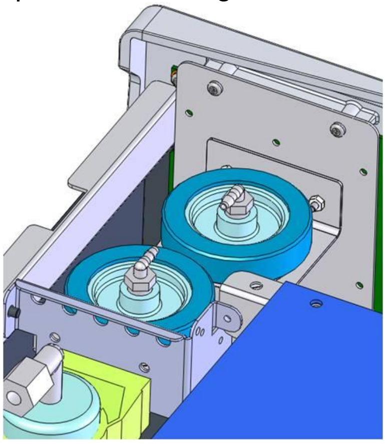


Figure 63 Dual filter option installed

Rack Mount Kit PN E020116

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

Included Items

1	Rack Slide Set	H010112
4	Rack Mount Adaptors	H010133
2	Rack Mount Ears	H010134
4	Spacers	HAR-8700
8	M6 x 20 Button Head Screws	
16	M6 Washers	
8	M6 Nyloc Nuts	
14	M4 x 10 Button Head Screws	
8	M4 Washers	
8	M4 Nyloc Nuts	
4	M4 x 10 Phillips Pan Head Screws	
8	M6 Cage Nuts	

Installing the Instrument

1. Remove the rubber feet from the analyser (if attached).
2. Separate the slide rail assembly by pressing the black plastic clips on the slide rails to remove the inner section of the rail. (refer to Figure 64).

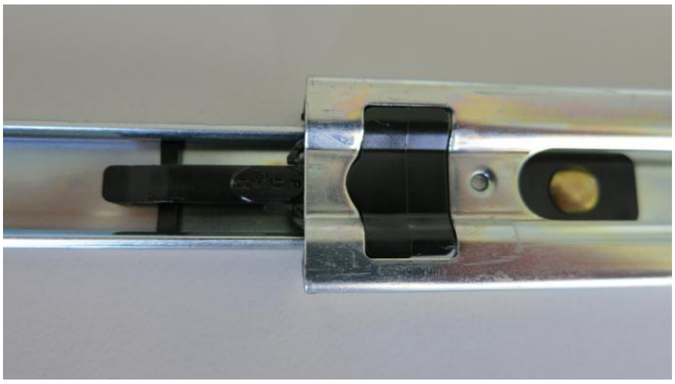


Figure 64 - Separate rack slides

3. Attach the inner slide rails to each side of the analyser using M4 x 10 button screws - three on each side. Ensure the vertical slotted holes are used and push the slide firmly downwards so that the screws sit at the top of the slot. This ensures that any protrusions under the base of the analyser do not hit any blanking panels which may be fitted. (refer to Figure 65).

Figure 65 - Assemble inner slide on chassis

4. Attach the rack mount adaptors to the ends of the outer slide rails using M4 x 10 button screws, washers and locknuts. Do not fully tighten at this stage as minor adjustments may be required to suit the length of the rack (see Figure 66).

Figure 66 - Attach rack mount adaptors to outer slides

5. Install the two assembled outer slide rails onto the left and right side of the rack securely with M6 bolts, washer and locknuts. It should be mounted at the front of the rack with the

fasteners for this claw located in the 5th and 7th hole of the vertical rail, counting from the bottom position of the instrument (refer to Figure 68).

Figure 67 – Rack installation

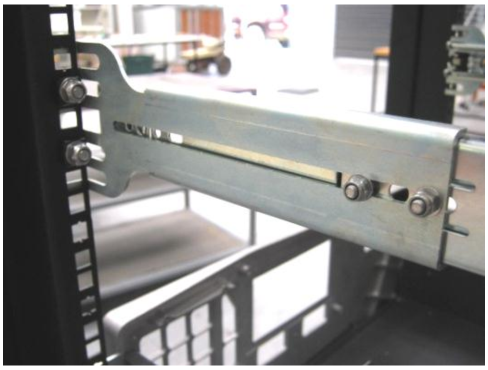


Figure 68 – Rack installation

6. Use a spacer (or cage nut) to space the rear claw from the side of the rack and a washer and locknut to secure it (refer to Figure 69).

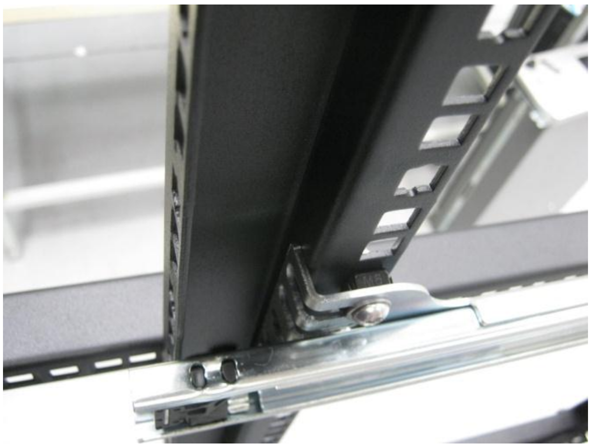


Figure 69 – Rack installation

7. Install rack mount ears on the front of the instrument using two M4 x 10 screws on each side (refer to Figure 70).

Figure 70 – Rack installation

8. Now carefully insert the instrument into the rack by placing the instrument slides into the mounted slides. Ensure that the rack slide locks engage on each side (you will hear a click from both sides). Gently slide the instrument into the rack.

Note: Ensure both sides of the inner slide are attached to the outer slides before pushing into the rack fully.

9. Push the analyser fully in. At this point, make sure that the analyser slides reach and locate in to the plastic catches at the rear end of the outer slides. Adjust the outer slides as required until this is achieved. Remove analyser and now tighten the M4 screws and nuts that secure the front and rear claws on both sides of the rack.

To Remove the Instrument

1. To remove the instrument first pull instrument out of rack giving access to the slides.
2. Find the rack slide lock labelled “push” and push it in whilst sliding the instrument out of the rack. Complete this for both sides before carefully removing instrument.

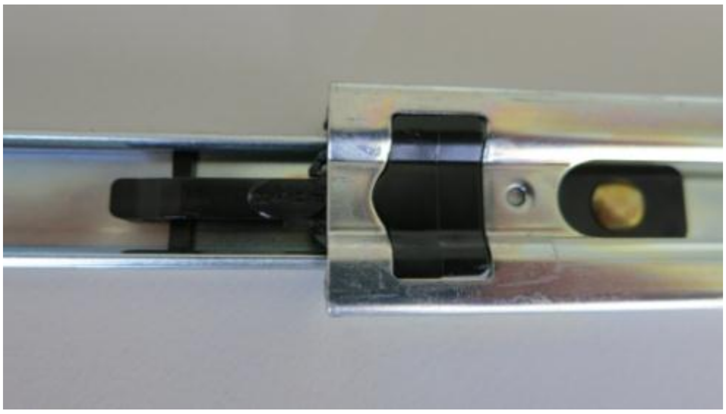


Figure 71 – Rack installation

Pressurised Zero/Span Valves

Single Pressurised Calibration Option

This option enables a pressurised cylinder of calibration gas or zero air to be permanently connected directly to the instrument, without the need for a dilution system or zero air system. This option controls and regulates the supply of the zero air or calibration gas into the instrument during calibration procedures. These are factory fitted options and you may choose either zero or span calibration valves or both.
PN E020108 High pressure span calibration valve (factory installed option)
PN E020109 High pressure zero calibration valve (factory installed option)

Operation of Single Calibration Option

When using the pressurised calibration option, either a high pressure zero or span bottle should be connected to the "Auxiliary In" port on the back of the analyser.

1. Ensure gas cylinder is fitted with an appropriate gas regulator including a shut off valve.
2. Connect a line of 1/8" stainless steel tubing between the gas cylinder and the analyser "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 check for leaks.
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 pressurised calibration.
9. Open the cylinder shutoff valve and 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 bars of pressure as this may cause a leak.

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.

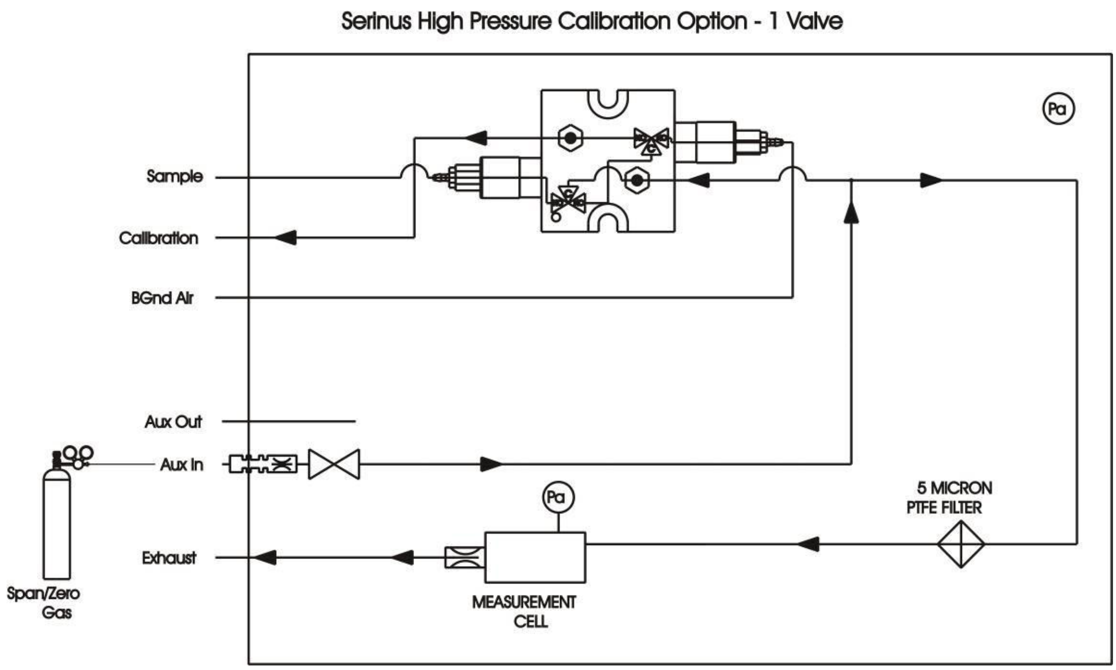


Figure 72 - Single high pressure calibration option

Dual Pressurised Calibration Option

This option enables a pressurised cylinder of calibration gas *and* zero air to be permanently connected directly to the instrument, without the need for a dilution system or zero air system. This option controls and regulates the supply of both the zero air and calibration gas into the instrument during calibration procedures.

Operation of Dual Calibration Option

When using the pressurised calibration option a high pressure zero bottle should be connected to the "Aux In" port and a high pressure span bottle connected to the "Calibration" port on the back of the analyser.

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 analyser 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 "Aux Out" port (used as a vent).
6. Change "Cal Port" to External (**Main Menu** → **Calibration Menu**) then select zero under the "Cal Mode" option this will initiate the pressurized zero calibration.
7. Open the zero cylinder shutoff valve and adjust the regulator pressure until the flow on the vent line (Auxiliary Out port) is between 0.5 and 1 LPM.
8. Change "Cal Port" to External (**Main Menu** → **Calibration Menu**) then select span under the "Cal. Mode" option this will initiate the pressurised span calibration.
9. Open the span cylinder shutoff valve; adjust the regulator pressure until the flow on the vent line (Aux Out port) is between 0.5 and 1 LPM.

Note: Do not exceed 2 bar of pressure as this may cause a leak.

Return to Normal Operation

1. Set Cal. Mode → Measure.
2. Remove the flow meter on the Auxiliary out 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.

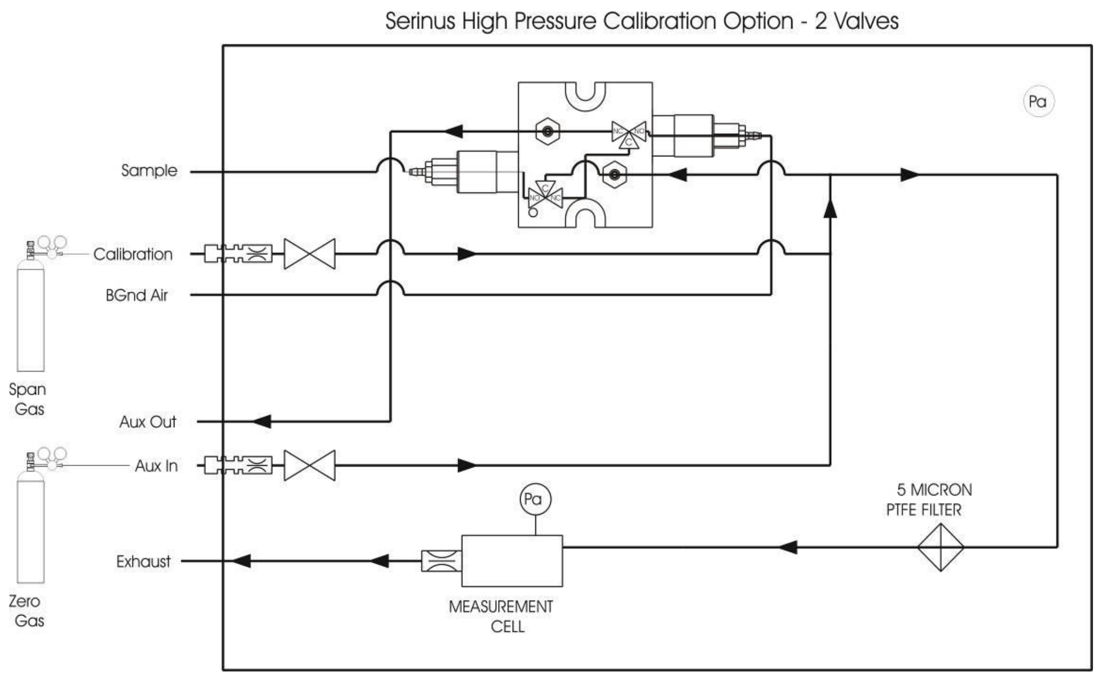


Figure 73 - Dual high pressure calibration option

High Level Option

The Serinus 40 high level option (E020113) allows measurement at higher ranges (0-1000ppm) with an LDL of 4ppb.
Changes to the instrument include:

- Delay coil removed (shown in Figure 74)

- Different flow orifice; 2 x H010043-02 (4 mil) replaces 2 x H010043-06 (8 mil)
- Different ozone office; H010043-03 (5 mil) replaces H010043-02 (4 mil)
- Lower sample flow rate: 0.17 SLPM will be displayed in "Sample flow" field (refer to Section 0)
- Exhaust pump should draw 0.52 SLPM (0.352 SLPM total flow)
- High level optical filter (H011205-01) installed within Rx cell assembly
- High Voltage pot set to approx 125 (refer to Section 0)

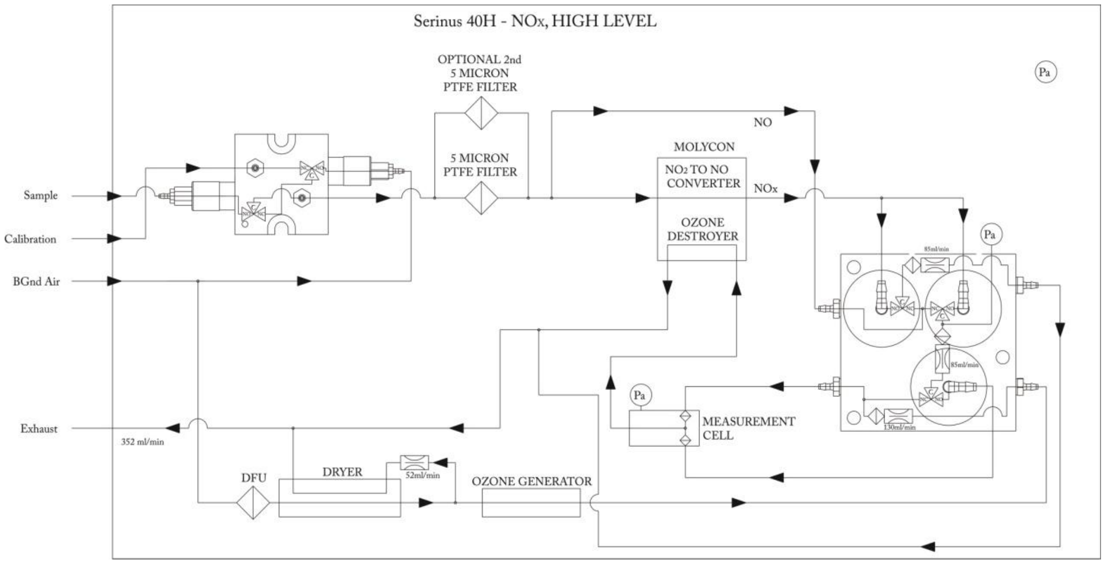


Figure 74 - Serinus 40 High level pneumatic diagram

This page is intentionally blank.

This page is intentionally blank.

Appendix A. Advanced Protocol Parameter List

Note: Parameters are for all Serinus analysers and may not be applicable to an individual analyser

Table 10 - 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	SO_2 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

#	Description	Notes
16	& PMT HIGH VOLTAGE Pot	High Voltage Controller Pot for PMT S50 & S40
17	SO_2 Lamp ADJ Pot	S50 Lamp Adjust Pot
18	O_3 Lamp ADJ Pot	S10 Lamp Adjust Pot
19	O_3 ZERO Measure Pot: Coarse	S10 Signal Zero (coarse)
20	O_3 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	SO_2 REFERENCE SIGNAL
26	Analogue input 1	CO REFERENCE SIGNAL
27	Analogue input 2	O_3 REFERENCE SIGNAL
28	Analogue input 3	SO_2 & O_3 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	SO_2 Measure SIGNAL Gain Pot	SO_2 Measure Signal Gain Pot
44	SO_2 REFERENCE Gain Pot	SO_2 Reference Signal Gain Pot
45	SO_2 SIGNAL ZERO	SO_2 Measure Zero Pot
46	O_3 SIGNAL GAIN POT	O_3 INPUT SIGNAL GAIN POT
47	Test Pot	Test Pot for all the analysers
48	NO_X Signal GAIN Pot	PMT signal input gain control FOR NO_X
49	PGA Gain	1, 2, 4, 8, 16, 32, 64, 128
50	Primary Gas Concentration	Current value on front screen

#	Description	Notes
51	Secondary Gas Concentration	Current value on front screen(if applicable eg NO_x
52	Calculated Gas Concentration	Gas 3 (eg:NO_2)
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	2-5
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	Ozone generator 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	O_3 Lamp Temperature	
83	Instrument Status	

#	Description	Notes
84	Reference Voltage	
85	Calibration State	0 = MEASURE 1 = CYCLE 2 = ZERO 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 0=Current
96	Output Type Gas 2	1=Voltage 0=Current
97	Output Type Gas 3	1=Voltage 0=Current
98	Voltage Offset /Current Range Gas1	0=0% or 0-20mA 1=5% or 2-20mA 2=10% or 4-20mA
99	Voltage Offset /Current Range Gas2	0=0% or 0-20mA 1=5% or 2-20mA 2=10% or 4-20mA
100	Voltage Offset /Current Range Gas3	0=0% or 0-20mA 1=5% or 2-20mA 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	Unsupported
109	NA	Unsupported

#	Description	Notes
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 1=PPB 2=PPT 3=mG/M³ 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	O_3 Generator Output	PPM
135	O_3 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

#	Description	Notes
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	O_3 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 analysers.
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", 2 = "ºK",
162	Pressure Units	0 = "torr", 1 = "psi", 2 = "mbar", 3 = "atm", 4 = "kPa"
163	Averaging Period	0 = " 1 Min", 1 = " 3 Mins", 2 = " 5 Mins", 3 = "10 Mins", 4 = "15 Mins", 5 = "30 Mins", 6 = " 1 Hr", 7 = " 4 Hrs", 8 = " 8 Hrs", 9 = " 12 Hrs",

#	Description	Notes
		10 = " 24 Hrs"
164	Filter Type	NO FILTER = 0, KALMAN FILTER = 1, 10 SEC FILTER = 2, 30 SEC FILTER = 3, 60 SEC FILTER = 4, 90 SEC FILTER = 5, 300 SEC FILTER = 6, ADPTIVE FILTER =7
165	NO_2 Filter	0 = Disabled, 1 = Enabled
166	Background Interval	0 = "24 Hrs", 1 = "12 Hrs", 2 = "8 Hrs", 3 = "6 Hrs", 4 = "4 Hrs", 5 = "2 Hrs", 6 = "Disable"
167	Service Baud	0 = " 1200 bps", 1 = " 2400 bps ", 2 = " 4800 bps ", 3 = " 9600 bps ", 4 = "14400 bps ", 5 = "19200 bps ", 6 = "38400 bps "
168	Multidrop Baud	0 = " 1200 bps", 1 = " 2400 bps ", 2 = " 4800 bps ", 3 = " 9600 bps ", 4 = "14400 bps ", 5 = "19200 bps ", 6 = "38400 bps "
169	Service Port (COM 1) Protocol	0 = " EC9800", 1 = "Bavarian", 2 = "Advanced"
170	Multidrop Port (COM 2) Protocol	0 = " EC9800", 1 = "Bavarian", 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

#	Description	Notes
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 1 = Over Ranging Enabled (Gas1)
175	Gas2 Over Ranging	0 = Over Ranging Disabled 1 = Over Ranging Enabled (Gas2)
176	Gas3 Over Ranging	0 = Over Ranging Disabled 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) Bit 31:26 ---- Year (0 – 99) Bit 25:22 ---- Month (1 – 12) Bit 21:17 ---- Date (1 – 31) Bit 16:12 ---- Hour (00 – 23) Bit 11:06 ---- Min (00 – 59) Bit 05:00 ---- Sec (00 – 59)
181	Instantaneous Manifold Pressure	Instantaneous Manifold Pressure in S40 analysers (no filter)
18 2	Calibration Pressure 2	
183	Gas 4 (NH_3) Concentration	
184	Gas 5 (N_X)Concentration	
185	Gas 4 (NH_3) Average Concentration	
186	NH_3 Conv. Efficiency	
187	Cell/Lamp M/S Ratio	
188	Mirror T. M/S Ratio	
189	Flow Temp M/S Rati0	
190	Cooler T. M/S Ratio	
191	NO Conv T. M/S Ratio	
192	CO Conv T M/S Ratio	
193	F/Scale Curr Gas 1	
194	F/Scale Curr Gas 2	
195	F/Scale Curr Gas 3	

#	Description	Notes
196	Z Adj Curr Gas 1	
197	Z Adj Curr Gas 2	
198	Z Adj Curr Gas 3	
199	Ext Analog Input 1	
200	Ext Analog Input	
201	Ext Analog Input	
202	Converter Set Point	

This page is intentionally blank.

This page is intentionally blank.

This page is intentionally blank.

This page is intentionally blank.

Appendix B. EC9800 Protocol

The following commands are supported.

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→PPM selected, CLEAR→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

All Bavarian Network commands follow the command format as specified in this section.

Bavarian Network Command Format

<STX><text><ETX>< bcc1><bcc2>

Where:

<STX> = ASCII Start Of Transmission = 0x02 hex

<text> = ASCII text maximum length of 120 characters

<ETX> = ASCII end of transmission = 0x03 hex

<bcc1> = ASCII representation of block check value MSB

<bcc2> = ASCII representation of block check value LSB.

The block check algorithm begins with 0 and exclusive-OR's 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 ID of 97:

<STX>DA097<EXT>3A

The block check calculation is best shown by the following example:

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 ID 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.

Supported Commands

The command set supported by the Bavarian protocol is:

Table 11 Bavarian Protocol Commands

Command	**Effect**
DA<id>	Returns gas concentration
DA	Returns gas concentration w/o id
ST<id> M	Enter Measure mode
ST<id> N	Enter Zero mode
ST<id> K	Enter Span mode
ST<id> S	Force a background check

DA

Return the current instantaneous concentration.
Format
<STX>{DA}{<kkk>}<ETX>< bcc1><bcc2>
or
<STX>{DA}<ETX>< bcc1><bcc2>
Where:
kkk = Device's multidrop ID
bcc1 = first byte of the block check calculation
bcc2 = second byte of the block check calculation
Device response (S10, S30, and S50 family)
<STX>{MD}{01}<SP><kkk><SP><+nnnn+ee><SP><ss><SP><ff><{000}><SP>{0000 0000}
<SP><ETC>< bcc1><bcc2>
Device response (S40 family)
<STX>{MD}{02}<SP><kkk><SP><+nnnn+ee><SP><ss><SP><ff><SP>{00000000}
<SP><mmm><SP><+pppp+ee><SP><ss><SP><ff><SP>{00000000}
<SP><ETC><bcc1><bcc2>
Where:
<SP> = space (0x20 hex)
kkk = Device's multidrop ID. If the DA command is issued without an ID, then the response omits this field. Exception: the S40 family always includes both ID fields, even when a DA command without an ID is issued.

+nnnn+ee = Main instantaneous gas concentration (for S40 family, this is NO)
ss = status byte with the following bit map:

Status Bit	Meaning if set to 1

0	Instrument off (this value is always set to 0)
1	Out of service
2	Zero mode
3	Span mode
4	-
5	-
6	Units: 1 = Volumetric, 0 = Gravimetric
7	Background mode (S30 and S50 family only)

ff = failure byte for both channels with the following bit map (positive logic):

Failure Bit	Meaning if set to 1
0	Flow sensor failure
1	Instrument failure
2	-
3	Lamp failure (S40 family only)
4	-
5	Cell heater failure (S30, S40 and S50 family only)
6	-
7	-

mmm = NO instrument ID
+pppp+ee = NOx gas concentration (unless the NO_2 option was selected in the **Serial Communications Menu**, in which case it is NO_2)
bcc1 = first byte of the block check calculation
bcc2 = second byte of the block check calculation

ST

Set the instrument mode.
Format
<STX>{ST}{< kkk>}<SP>{command}<ETC><bcc1><bcc2>
Where:
kkk = Device's multidrop ID
command = M, N or K for Measure, Zero, or Span mode
bcc1 = first byte of the block check calculation
bcc2 = second byte of the block check calculation

This page is intentionally blank.

This page is intentionally blank.

This page is intentionally blank.

This page is intentionally blank.

This page is intentionally blank.

Appendix D. ModBus Protocol

The Serinus supports a limited Modbus implementation.
The only function codes supported are 3 (Read holding register) and 16 (Write multiple registers).

Read Holding Register

You must specify a slave address for Serial requests (but not for TCP requests). This value is the Serinus's Multidrop ID.
Read requests specify which Advanced Protocol IEEE value they want to read as the starting reference (indexed from 0). Refer the appendix on the Advanced Protocol to see what values are available and what index to specify for them.
You may read from 2 to 124 registers. Note that you must read an even number of registers, because the return data is always 4 bytes (a float).
The Serinus expects 8 data bits, 1 stop bit, and no parity. The baud rates is specified by the **Serial Communications menu**.
The value will be returned as a big-endian 32-bit IEEE floating point value.

Write Multiple Registers

You must specify a slave address for Serial requests (but not for TCP requests). This value is the Serinus's Multidrop ID.
The start reference is the same as for reading.
Only 2 registers may be written at a time; that is, a single IEEE value. Currently only the supported value is 85, to put the instrument into span (3), zero (2), cycle (1), or measure (0) mode.

ecotech
environmental monitoring solutions

1492 Ferntree Gully Road,
Knoxfield VIC Australia 3180
Phone: +61 (0)3 9730 7800
Fax: +61 (0)3 9730 7899
General email: info@ecotech.com
International support: intsupport@ecotech.com
www.ecotech.com