ecotech
environmental monitoring solutions

Aurora 1000

Single Wavelength Integrating Nephelometer

User Manual

Version: 1.5

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Manufacturer's Statement

Thank you for selecting the Aurora 1000 Integrated Nephelometer. The Aurora 1000 is a single-wavelength nephelometer with innovative design features, designed primarily for visibility and particulate sampling. By following the guidelines contained in this manual and with the implementation of a good quality-assurance program, the user can obtain accurate and reliable data

The Aurora 1000 Integrating Nephelometer uses a single wavelength for visibility measurements at either of three wavelengths (450nm, 525nm or 635nm). The Aurora 1000 is a product of exceptional quality capable of producing years of maintenance free operation.

This User Manual provides a complete product description including operating instructions, calibration, and maintenance requirements for particulate sampling techniques.

If, after reading this manual you have any questions or you are still unsure or unclear on any part of the Aurora 1000 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 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.

The Aurora light source is covered by the following patent:

U.S. Patent Office 7, 671, 988

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

Each nephelometer is subjected to a vigorous testing procedure prior to despatch and will be accompanied with an instrument test report. The nephelometer is ready for installation and normal operation.

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 instrument.

Service Guidelines

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

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 Aurora 1000 Single Wavelength Integrating Nephelometer as manufactured by Ecotech Pty. Ltd. of 1492 Ferntree Gully Rd, Knoxfield, VIC, 3180, Australia, and which may be sold in the following configurations:

Part Number	Description
E010001	Aurora 1000G Integrating Nephelometer 525nm
E010002	Aurora 1000R Integrating Nephelometer 635nm
E010003	Aurora 1000B Integrating Nephelometer 450nm
E010005	Aurora 2000G Integrating Nephelometer 525nm

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.

EN61326-1 Immunity requirements

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

EN61326-1 Electromagnetic compatibility

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 harmonisation 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 container/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 documents are 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 container.

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

Please refer to the instrument name, model number, serial number, sales order number, and your purchase order number on all claims.

You should also:

- Contact you freight forwarder for an insurance claim.
- Retain packing material for insurance inspection.

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

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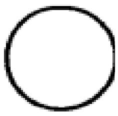
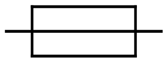
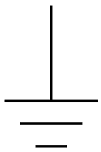
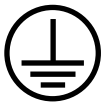
Internationally Recognised Symbols on Ecotech Equipment

	On (Supply)	IEC 417, No. 5007
	Off (Supply)	IEC 417, No. 5008
	Electrical fuse	IEC 60417-5016
	Earth (ground) terminal	IEC 60417-5017
	Protective conductor terminal	IEC 60417-5017
	Equipotentiality	IEC 60417-5021
	Direct current	IEC 417, No. 5031
	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:	M010001
Current revision:	1.5
Date released:	7 September 2013
Description:	User Manual for the Aurora 1000 Single Wavelength Integrating Nephelometer

This manual is the full user manual for the Aurora 1000 Single Wavelength Integrating Nephelometer. 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	Affected Pages
1.00	November 2007	Initial release	all
1.1	October 2008	Updated mounting procedure Updated initial check Calibration tolerance updated	44 39 63
1.2	February 2009	Amended analogue outputs	81
1.3	May 2009	Updated light source information	Various
1.4	May 2011	Included flow control option	108
1.5	September 2013	Updated general information for CE requirements Formatting changes	Various All

1. Introduction

1.1 Description

The Aurora will measure, continuously and in real-time, light scattering in a sample of ambient air due to the presence of particulate matter. (Specifically, the scattering coefficient σ_{sp}) The measured values are adjusted automatically and in real-time by on-board temperature and pressure sensors.

Calibrations and zero/span checks are fully automatic, with checks initiated automatically, at user-selectable intervals. There is provision for several types of calibration gases.

A processor-controlled sample heater can eliminate the effects of relative humidity on scattering behaviour. The heater can be enabled and disabled by the user.

All these options are available from an easy-to-use menu system with a large 4-line backlit LCD display and keypad mounted on the instrument case.

Over 61 days' data can be stored in the internal data logger for later downloading through the RS-232 port. Instantaneous data can also be logged externally via the RS232 port or by using the four (4) real-time analogue outputs.

The Aurora also features low power consumption, very long-lasting and reliable LED's as the light source and has an exceptional signal-to-noise ratio.

1.2 Specifications

1.2.1 Measurement

Range

Measurement:	0 to 20,000 Mm^{-1}
Light scattering angle:	9° – 170°
Wavelength:	450nm, 525nm or 635nm

Lower Detectable Limit

< 0.3 Mm^{-1} over 60 seconds integration

Sample Flow Rate

5 l/minute approximately

1.2.2 Calibration

Calibration Gases Supported

CO_2	SF6
FM-200	R-12
R 22	R-134

Automatic Calibration Intervals

3, 6, 12, 24 hours, weekly or user designated day

Automatic Calibration Types

Zero Check

Span Check

Zero and Span Check

Zero Adjust

1.2.3 Power

Operating Voltage

110-250VAC 50 or 60Hz

11-14VDC

Power Consumption

60VA max

1.2.4 Operating Conditions

Ambient Temperature Range

-20 -45°C

Relative Humidity

10-90%

Altitude

3000m	normal operation
10,000m	aircraft operation (12V supply only)

1.2.5 Physical Dimensions

Case Dimensions

LxWxH = 175 x 700 x 235 mm (with feet)

Weight

11.2kg

Total Cell Volume

1890 cm^3

Illuminated Optical Volume

10.5 cm^3

1.2.6 Communication & Data

Communications Ports

1 multi-drop (RS232)

1 Service port (RS232)

External I/O

Analog:

2 Voltage outputs

2 Current outputs

2 digital inputs

1 digital output

Data Properties

Averaging period:	1 or 5 minutes
Stored properties:	σ_{sp}, Air Temperature, RH, Pressure, Enclosure Temperature, Time, Visibility
Capacity:	61 days (5 min)
	12 days (1 min)

1.3 Nomenclature

Span

When gas of known Rayleigh factor is passed through nephelometer and measured as a reference. This measurement is used to correct measure coefficients.

Zero

When air with no particulate matter is passed through nephelometer and measured as a reference. This measurement is used to ascertain the effect of air (CO_2 , CO, O_3, N_2 etc) on scattering coefficient.

Shutter Count

The shutter count is the measurement of light shone directly through a dark glass (reference shutter) with known transmittance. This measurement is used as a reference for light intensity and PMT measurement.

Dark Count

Measures background light scattering when light source is off (should be 0 but readings less than 200 are considered typical). It is used to subtract from measure count to eliminate noise from background interference.

Measure Count

Raw measurement of the light scattering of particulates in the sample air within the cell.

1.4 Background/Theory

The effects of air pollution on human health and lifestyle are of a major concern today. There are many parameters contributing to air pollution, airborne particulates are a major contributor.

The Ecotech Aurora 1000 Integrating Nephelometer measures σ_{sp}, the scattering coefficient of light due to particles.

σ_{sp} may be used as a measure of particulate pollution, the higher the value of σ_{sp} the higher the concentration of particles. It may also be used as a measure of atmospheric visibility, the higher the value of σ_{sp} the lower the visibility.

The dimension of σ_{sp} are inverse length. The Aurora 1000 reports σ_{sp} in units of the inverse megametre (Mm^{-1}). Conversion factors are:

1 Mm^{-1} = 10^{-3} km^{-1} (inverse kilometres) = 10^{-6} m^{-1} (inverse metres).

1.4.1 Background

Extinction Coefficients σ_{ext}

Attenuation of light (that is, reduction in its intensity) is usually expressed using the Beer-Lambert law:

$$I = I_0 e^{-\sigma_{ext} x}$$

Equation 1 – Beer-Lambert law

where:

I_0 = initial light intensity,

I = intensity after distance x,

x = distance,

σ_{ext} = the attenuation, or extinction coefficient.

(sometimes the symbol b is used instead of σ_{ext})

The relationship between extinction coefficient and visual range is expressed in Koschmieder's Formula.

$$L_v = 3.912 / \sigma_{ext}$$

Equation 2 – Koschmieder's formula

where:

L_v = visual range,

σ_{ext} = extinction coefficient.

The larger σ_{ext}**,** the more rapidly the light is attenuated (ie reducing visibility).

Assumptions

Light may be attenuated either by scattering off objects or absorption by objects. Thus the extinction coefficient σ_{ext} may be broken down into a scattering coefficient σ_{scat} and an absorption coefficient σ_{abs}:

$$\sigma_{ext} = \sigma_{scat} + \sigma_{abs}.$$

Equation 3 – Light attenuation equation

For light attenuation in the atmosphere, the objects responsible can be either gas molecules or airborne particles. The scattering and absorption coefficients may therefore be further broken down into

$$\sigma_{scat} = \sigma_{sg} + \sigma_{sp}$$

Equation 4 – Scattering coefficient

and $$\sigma_{abs} = \sigma_{ag} + \sigma_{ap},$$

Equation 5 – Absorption coefficient

where the subscripts denote:

s: scattering
a: absorption
g: due to gas molecules
p: due to particulate matter

σ_{sp}, for example, is the extinction coefficient due to scattering from particulate matter. Scattering due to gas molecules (coefficient σ_{sg}) is also called Rayleigh scattering.

NO_2 is the most significant gaseous absorber and soot the most significant particulate absorber. However, except in extremely high concentrations, the effects of absorption are negligible compared to the effects of scattering. Therefore, to a very good approximation:

$$\sigma_{ext} \approx \sigma_{scat} = \sigma_{sg} + \sigma_{sp}$$

Equation 6 – Relationship of extinction coefficient with scattering coefficient

It is σ_{scat} that the Aurora 1000 measures directly. When the nephelometer performs a zero adjust in particle-free air (that is, where only Rayleigh scattering is present), the σ_{sg} component of σ_{scat} is subtracted leaving σ_{sp} as the reported parameter.

Higher particulate concentrations mean more scattering, so σ_{sp} is a good measure of particulate pollution.

In urban situations σ_{sp} will be much greater than Rayleigh scattering (σ_{sg}). σ_{sp} is therefore also a good measure of atmospheric visibility.

Effects of Wavelength

Absorption and scattering are dependent on the wavelength of the incident light. In the Aurora 1000 either one of three different wavelengths can be chosen (450nm, 525nm or 635nm). Each wavelength interacts differently with particulate matter and thus differences in particulate composition can be inferred.

- 450nm (blue) interacts strongly with fine and ultrafine particulates (wood fires, automobiles).
- 525nm (green) interacts strongly throughout the human range of visibility (smog, fog, haze).
- 635nm (red) interacts strongly with large particulate matter (pollen, sea salt).

These different wavelengths overlap in measurements and do not directly measure differences in particulate composition, they merely infer differences.

Effects of Humidity

Above approximately 40% relative humidity, particles collect water droplets and grow because of the water vapour condensing on them, hence scattering more light.

The Aurora contains an internal heater which if enabled (refer to section 3.5.5) heats the incoming sample when the relative humidity of the air sample rises above a threshold chosen by the user. This decreases the relative humidity and evaporates the water droplets.

Switching on the heater (dry measurement) would give a more reliable measure of airborne pollutant concentrations, as this evaporates (much of) the water droplets. It has to be noticed, however, that volatile compounds will also be evaporated in the process and that using a nafion type of dryer is more advisable.

Please consult your local standards to determine at what relative humidity the measurement should be performed.

1.4.2 Measurement Theory

During normal operation three main measurements are undertaken. They are shutter count, dark count and measure count.

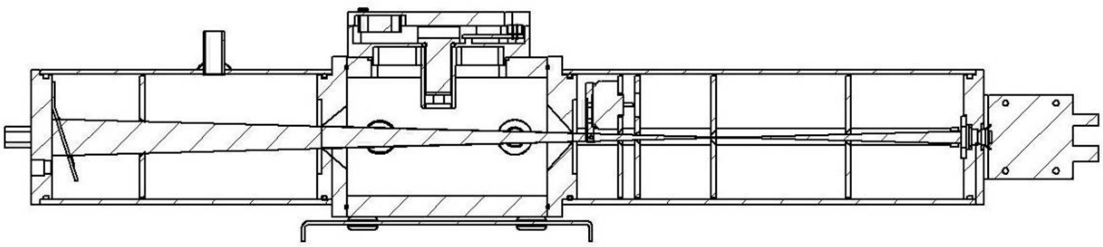


Figure 1 – Light path layout

Shutter Count

Periodically (every 30 seconds) the shutter mounted inside the cell (refer to Figure 1), is closed for about 4 seconds. During this time, there is a direct light path from the Light Source, to the shutter and then to the photomultiplier tube. The shutter glass is a material with known transmittance that allows the nephelometer to adjust for variations in the measuring system.

This measurement does not rely on air scattering. The results from the shutter measure are stored as the shutter count and should be in the order of 0.8M to 1.6M.

Dark Count

The light source periodically flashes on and off in less than 1 second. When the light source is off, the PMT measures the dark count. That is, the background light incident upon the PMT when the light source is off. Ideally, this should be 0, however readings from 0 to 500 are normal, as are small fluctuations.

Measure Count

The measure count is taken when the shutter is open and the light source is on. The measured counts from the PMT are a result of scattering due to gaseous and particulate matter inside the measurement volume. As the concentration of scattering components inside the cell increases, so do the measure counts. Typical measure counts can vary from 5k to 500k.

Measure Ratio

The measure ratio (MR) is the ratio between the measure count (C_m) and the shutter count (C_{sh}).

$MR = C_m / C_{sh}$

Eg. If $C_m = 15,000$ & $C_{sh} = 1,200,000$, then $MR = 12.5 \times 10^{-3}$.

Because the C_{sh} is a known source, the MR is directly proportional to σ_{scat}.

If there are changes in the measurement system (ie. Light intensity or temperature), then both C_m & C_{sh} will change proportionally. Therefore the MR will remain constant. However if the σ_{scat} of the sample changes, then only the C_m will vary.

Kalman Filter

The Aurora 1000 has the option of using a fixed 30 second Moving Average Filter or the advanced digital Kalman filter (selectable from the **Report Prefs Menu**).

The Kalman filter provides the best possible compromise between response time and noise reduction for the type of signal and noise present in the ambient air.

Ecotech's implementation of the Kalman filter enhances the Aurora 1000 measurement method by making the time constant variable, depending on the change rate of the measured value. If the signal rate is changing rapidly, the nephelometer is allowed to respond quickly. When the signal is steady, a longer integration time is used to reduce noise. The system continuously analyses the signal and uses the appropriate filtering time. The output from the Kalman filter is updated every second.

1.4.3 Calibration Theory

During a calibration, calibration gas and particle free air are passed through the cell at different times. Both these components have known values of σ_{sp} and σ_{sg}. When the measure ratio for these components is plotted against the known σ_{sp}, a linear relationship can be formed between σ_{sp} and measure ratio.

Note: The effects of dark count and other variations measured through the shutter count are compensated for in this relationship.

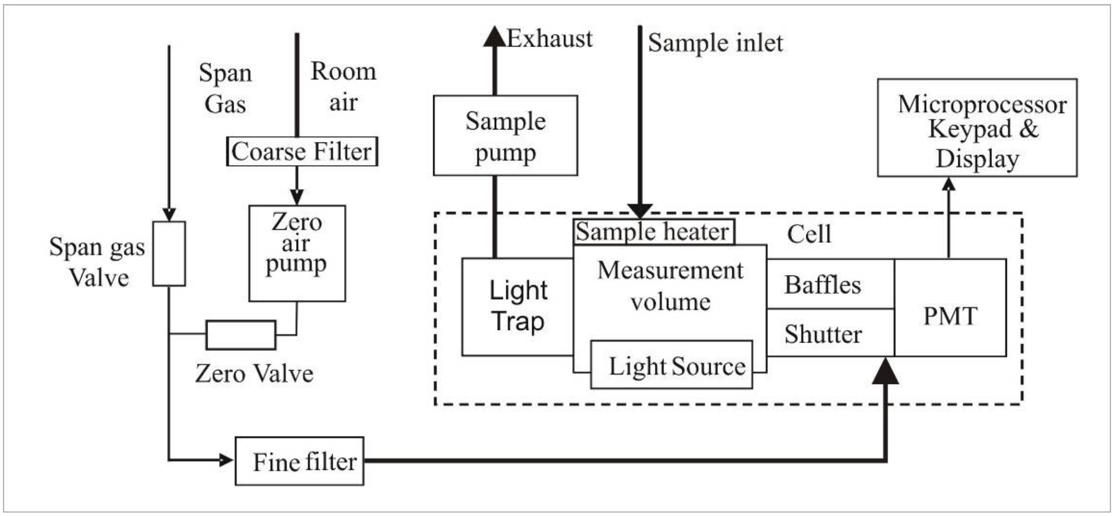


Figure 2 – Block diagram

Zero calibrations are performed with zero air to subtract the Rayleigh scattering component) of σ_{scat}. Span calibrations are performed using certified gas, typically CO_2 or FM-200 gas (HFC-227ea Heptafluropropane).

Calibration Example

The following is an example of a typical calibration using CO_2 calibration gas with 525nm (green light source).

During a full calibration two points are measured.

- The span point is measured with CO_2 calibration gas.
- The Zero point is measured with particle free air.

During the calibration, the Aurora measures the C_m & C_{sh} as well as sample temperature (ST) and barometric pressure (BP). The following results are obtained.

Table 1 – Calibration data

Point	Span	Zero
C_m (Hz)	13692	11582
C_{sh} (Hz)	1,200,000	1,200,000
MR (C_m/C_{sh})	11.41×10^{-3}	9.65×10^{-3}
ST (°K)	300.2	300.2
BP (mBar)	1004	1004
σ_{scat} (10^{-6} m)*	24.79	0

At STP (273.15 °K, 1013.25mBar) and wavelength 525nm:

σ_{scat} for particle free air (Air Rayleigh) $= 14.82 \times 10^{-6}$ m.

σ_{scat} for CO_2 $= 2.61 \times 14.82 = 38.6802 \times 10^{-6}$ m. (2.61 is the known multiplier of CO_2).

*Use STP normalisation to calculate the σ_{scat} at 300.2 ° K & 1004mBar as measured in Table 1.

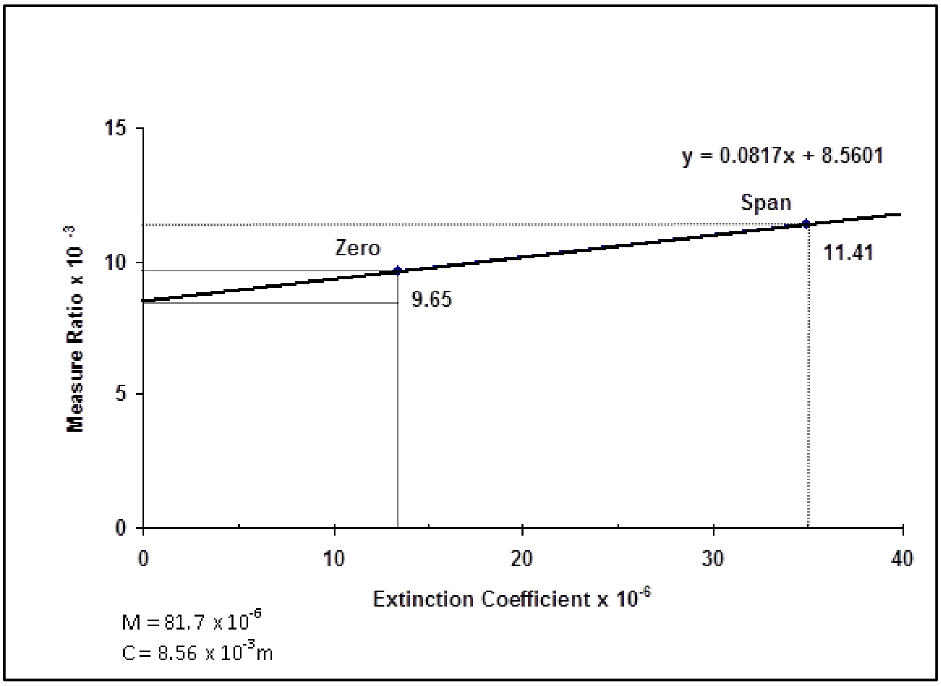


Figure 3 – Aurora calibration curve

The values for σ_{scat} and MR are plotted on the above calibration curve. From this curve we can obtain a formula for converting the MR to σ_{scat}.

$\sigma_{scat} = (MR - 8.56) / 0.0817\ (10^{-3})$

If for example our MR = 10 then,

$\sigma_{scat} = 17.63 \times 10^{-6}$m.

In the Aurora 1000 all results are reported with Air Rayleigh subtracted.

$\sigma_{sp} = \sigma_{scat} - \sigma_{sg}$ where $\sigma_{sg} = 17.63 - 13.36 = 4.26\ 10^{-6}$m.

Calibration Stability

When a full calibration is completed, the Aurora reports a value for Cal Stability. This is an indication of the variation of readings about the mean.

Given 150 samples, let x be the mean and s be the standard deviation.

Cal Stability = 100 * (1 - 2s/x).

If Cal stability = 95%, then the standard error = 2.5%.

Typically during a calibration of either span or zero, a Cal stability of > 95% should be achieved.

Wall Signal

The Wall signal is the amount of scattering contributed as a result of internal reflections within the cell and foreign matter. As the cell becomes dirty, the wall signal will increase. The wall signal will also be different for different wavelengths. The wall signal is calculated after a full calibration. Looking at the graph of figure 3 the wall signal can be calculated as follows:

Wall = 100x (C / $MR_{(ZERO)}$) = 100 x (8.56 / 9.65) = 88.7%.

- For Red wavelength (635nm) it should be in the range of 80% to 90%.
- For Green wavelength (525nm) it should be in the range of 70% to 85%.
- For Blue wavelength (450nm) it should be in the range of 50% to 65%.

A 5% increase in wall signal is considered a good indication of when to clean the cell.

Calibration Gas Constants

Table 2 lists the σ_{sp} for the supported calibration gases at different wavelengths and at STP.

The general formula to calculate the coefficient at a different wavelength:

$$\sigma_{sp}(\lambda_1) = \sigma_{sp}(\lambda_2)\left(\frac{\lambda_2}{\lambda_1}\right)^4$$

So for example:

$$\sigma_{sp}(450) = \sigma_{sp}(525)\left(\frac{525}{450}\right)^4$$

Note: The following table shows the calibration gas constants used by the Aurora during a full calibration. The Aurora readings are with Air Rayleigh subtracted so that for clean particle free air (zero), the Aurora Nephelometer reads 0. All values are at STP (273.15°K, 1013.25mBar).

Table 2 – Properties of calibration gases at different wavelengths

Gas Constants							
Wavelength	Rayleigh air	CO_2	fm200	SF6	r12	r22	r134
		2.61	15.3	6.74	15.31	7.53	7.35
450	27.46	71.67	420.14	185.08	420.41	206.77	201.83
525	14.82	38.68	226.75	99.89	226.89	111.59	108.93
635	6.92	18.07	105.95	46.64	105.95	52.14	50.90
Aurora Readings							
Wavelength		CO_2	fm200	SF6	r12	r22	r134
450		44.21	392.68	157.62	392.95	179.31	174.37
525		23.86	211.93	85.07	211.93	96.77	94.11
635		11.15	99.02	39.72	99.02	45.22	43.97

1.5 Instrument Description

The Aurora 1000 measures σ_{sp} in the following way:

- Sample air is drawn through the sample inlet into the measurement volume and exits through the sample outlet via the pump.
- The light source illuminates the sample air in the measurement volume.
- Gaseous and particulate components of the sample air will cause the light to scatter.
- The baffles inside the optical chamber are positioned so that only light scattered inside a narrow cone, at scattering angles between 10° and 170°, reaches the photomultiplier tube and so that multiple scattered light is unlikely to reach the photomultiplier tube.
- The photomultiplier tube produces electrical signals proportional to the intensity of the incident light. Hence the signal produced by the photomultiplier tube is proportional to the scattering coefficient of the sample air, σ_{scat}.
- The light trap and other baffles eliminate unwanted reflections from the light source and scattered light off the non-detecting end of the cell. The cell interior and baffles are coated with a special mat finish black paint to reduce any internal reflections.

After removing the front cover, you will see the Aurora's components. The following is a brief description of each of these components.

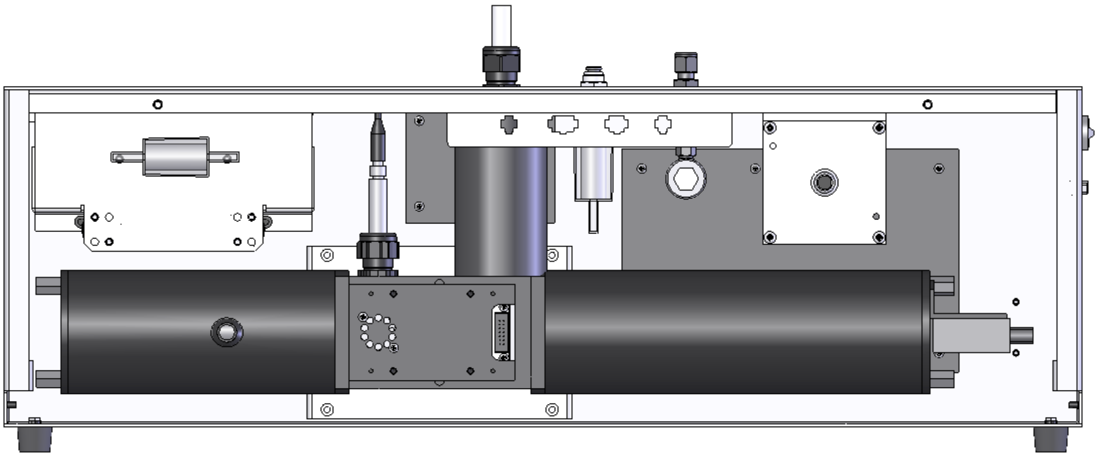


Figure 3 – Aurora 1000 (with cover removed)

1.5.1 Cell

The cell is the critical part of the Aurora. It is within cell that the optics, the electronics and the pneumatics all come together. The cell pneumatically and optically sealed to prevent stray light and air from entering. It is made of black anodised aluminium with a coating of matt black paint on the inside to reduce internal wall scatter.

Figure 4 – Cell

1.5.2 PMT

The PMT (Photo Multiplier Tube) is used to measure the light (photons) resulting from scattering. It is actually a photon counting head and produces an electrical signal (frequency) proportional to the incident light. The output frequency of the PMT ranges from 0 Hz to 1,600,000 Hz. The high voltage supply to operate the PMT is internally generated within the PMT. There is a black rubber cover over the PMT to reduce stray light from increasing the dark counts.

Figure 5 – PMT

1.5.3 Shutter

The shutter is used to periodically check the operation of the Aurora as well as compensates for any variations in the measuring system. i.e. variations in light source intensity, or wall scatter. The shutter composes a solenoid and a piece of glass with known transmittance. It is mounted on a rotary solenoid and is switched in and out of the optical path. Typically when the shutter is switched in it will give a shutter count of around 0.8M-1.6M (though this number can vary depending on PMT sensitivity and light source intensity).

Figure 6 – Shutter

1.5.4 Light Source

The light source uses high powered LEDs (Light Emitting Diodes) of a specific wavelength (450nm, 525nm or 635nm). LEDs are used instead of the conventional flash lamps because of much better reliability, stability and lower heating of the sample. Integration can also be performed over a longer period of time because LEDs can be turned on for longer.

The LED's are housed in a black assembly which can be easily removed for cleaning purposes. On the front of the Light Source housing there is an opal glass diffuser.

Figure 7 – Light source

The opal glass diffuser ensures that the LEDs produce light with a lambertian distribution.

1.5.5 Sample Pump

The sample pump is the means by which large volumes of ambient air is drawn in through the sample inlet, through the cell and out the exhaust. This pump runs continuously drawing 5 l/min except during calibration and start-up.

Figure 8 – Sample pump

1.5.6 Zero Pump

The zero air pump is a +12V DC diaphragm pump which pumps air through the fine filter providing particle free air (zero calibration or zero check). It is not on during normal measuring mode. The zero pump has a DFU filter on its inlet to protect it from the build-up of dust.

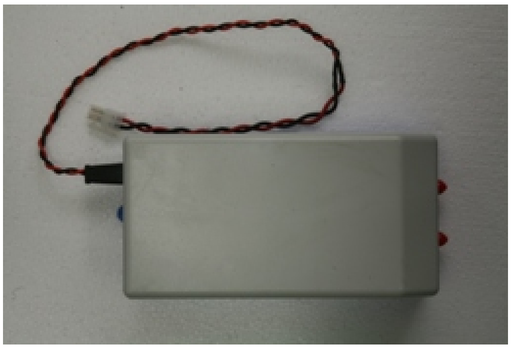


Figure 9 – Zero pump

1.5.7 Zero/Span Fine Filter

The zero filter works in conjunction with the zero pump to provide the particle free air during zero calibration and zero check. Its filtration efficiency is greater than 99.5% removing particles greater than 0.1 micron in size.

Figure 10 – Zero filter

1.5.8 Span & Zero Valve

The span valve and zero valve are +12V solenoid valves which are opened during a span calibration/span check or zero calibration respectively. When opened, it allows the calibration gas/zero air to pass into the cell for calibration.

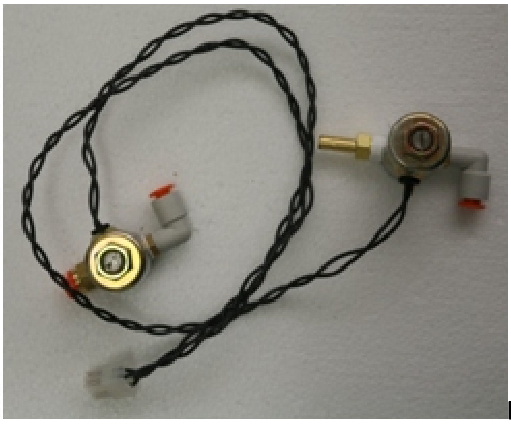


Figure 11 – Span and zero valve

1.5.9 Temperature/RH Sensor

The temperature and RH sensor is mounted on top of the cell measuring directly in the cell. The temperature and RH is monitored by the microprocessor and the data recorded in the internal data logger.

- The temperature/RH sensor measures the sample air temperature and is used in the calculation and compensation of σ_{sp} for STP (Standard Temperature and Pressure).
- The temperature/RH sensor is also used to control the sample heater, hence controlling the sample temperature up to the desired set point. OR
- The temperature/RH sensor can also be used to control the sample heater, hence controlling the RH of the sample air down to the desired set point.

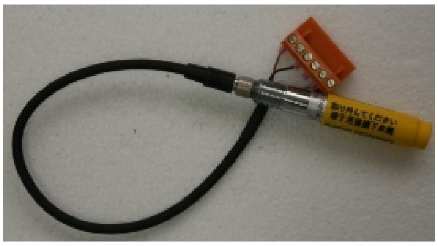


Figure 12 – Temperature/RH sensor

1.5.10 Pressure Sensor

The air pressure sensor is mounted on the microprocessor board. It is connected pneumatically to the cell to measure the cell pressure. The measured pressure is used to calculate and convert the σ_{sp} to Standard Temperature and Pressure during normal sampling and calibration. The pressure is logged internally on the data logger. It is also used during the leak check procedure.

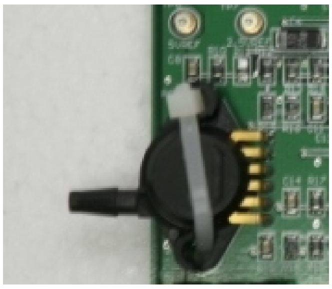


Figure 13 – Pressure sensor

1.5.11 Sample Heater

The sample heater comprises of two separate heaters: the cell heater and the inlet heater. When enabled, they operate together to heat the sample, first through the inlet and then the within the measurement cell. The sample temperature is measured using the sample temperature/RH sensor and is mounted in the cell near the inlet. The microprocessor controls the sample heater so that the sample air in the cell is kept at the desired set point of temp or RH.

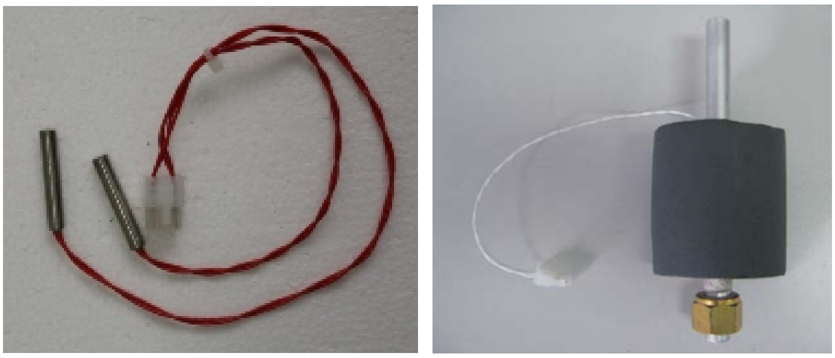


Figure 14 – Cell & inlet heaters

If the Aurora is installed in a room where the sample inlet is taking in outside air and the room temperature is much cooler than the ambient temperature, then the sample heater should be set to the temperature of average ambient temperature (25-30°C).

If the Aurora is running from batteries (+12v Operation) then the sample heater should be disabled in order to extend battery life.

1.5.12 Microprocessor

The microprocessor board is the heart of the Aurora 1000. It takes the raw count data from the PMT and converts them to real σ_{sp} values. It controls all the pumps, solenoids and light source. It internally logs the data and provides RS232 data and remote control capabilities. It also controls the LCD display and keypad allowing the user to view and modify parameters.

The firmware (program) loaded on the microprocessor board is stored in EEPROM and can be upgraded via the serial port. It also contains a real time clock for data logging and auto calibration control. The calibration parameters and user settings are also stored in FLASH ROM, so they are not lost during a power failure.

Figure 15 – Microprocessor board

1.5.13 Keypad & Display

The keypad and display provide the user with an interface so that they can input and retrieve vital operational data. The membrane Keypad comprises of 6 keys for easy access to the menu system.

The display comprises of a backlit 4 x 16 character LCD displays for displaying data clearly. Refer to section 3.2.1 for more details.

Figure 16 – Keypad & display

1.5.14 Back-up Battery

The back-up batteries are located next to the microprocessor board. They provide power to the real time clock and logged data when the Aurora is turned off.

Note: If you disconnect the battery while the power is off, the clock settings and logged data will be lost. However calibration and setup parameters will not be lost. The batteries are two AA 1.5V alkaline cells.

1.5.15 Electrical Connections

The following connections are found on the right side of the nephelometer (when looking at the screen). The placement of these electrical and communication connections is designed to minimise any interference from liquid spills or dust build-up.

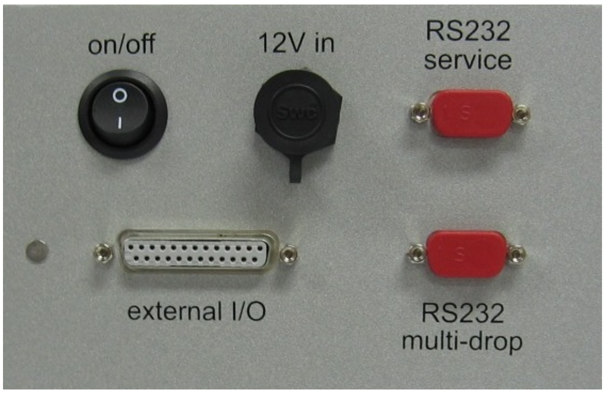


Figure 17 – Electrical connections to Aurora 1000

RS232

There are two RS232 serial ports available on the Aurora 1000, the multi-drop and service ports. The Multi-drop serial port is used for communication and data download. It can be connected to data logger in a daisy chain configuration allowing multiple instruments to be logged using one serial port. The service port is used for diagnostic and remote control purposes. Refer to section 3.5.8 for further details on setting up the RS232 ports.

External I/O

The external I/O port is used to connect the analog outputs as well as external span and zero controls. Refer to section 2.2.3 for further details.

11V - 14V in

The12V inlet is where the 12V power pack or external battery is connected. This supplies the power for the nephelometer which will not operate if not plugged in. The Power switch is located on the left side of the connector and must also be turned on (switched down) for the nephelometer to work.

1.5.16 Pneumatic Inlets

The pneumatic inlet connections for the Aurora are located on the top of the nephelometer case (when looking at the screen) so that inlet tubing can be positioned directly above the case.

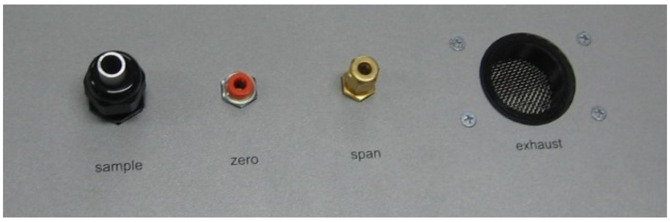


Figure 18 – Pneumatic connections to Aurora 1000

Sample

The ½” port labelled “sample”, is where the sample inlet is connected. During transport or storage, this port should be closed to avoid debris from falling into the cell.

Zero

The Aurora has its own internal filters for generating particle free air. There is no need for any further connections on the zero gas port.

Span

The calibration gas used for calibrating the Aurora is connected here as discussed in section 2.2.1.

CAUTION
Do not leave FM200 gas connected to the Aurora for long periods of times as this may cause condensation and damage to the calibration control kit.

Exhaust

The exhaust is located at the top of the nephelometer to the right side of the other pneumatic connections. The exhaust is pumped up through this outlet which has the ability to be vented out with a screw in exhaust hose (optional). If using the optional exhaust hose, always ensure that the outlet of the hose is at a higher elevation than the Aurora enclosure. This will ensure stable calibration results.

Note: During normal operation make sure the exhaust is not covered.

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2. " Installation

The correct installation of the Aurora is very important to ensure that the nephelometer operates correctly and gives you reliable data. Please read the following sections carefully.

2.1 Initial Check

Packaging

The packaging which the Aurora 1000 is transported in 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 nephelometer is going to be relocated.

Remove all packaging including red caps from nephelometer and store in a secure area. In the event that the packaging is to be disposed of, all the materials used are recyclable and should be disposed of accordingly.

Items Received

With the delivery of the Aurora 1000, you should have received the following:

• Ecotech Aurora 1000 nephelometer		PN: E01000X*
• Power cord		PN: -------------
• Serial cable		PN: COM-1451
• Manual	(optional)	PN: M010001
• Software Utilities CD.		PN: S040001-01
• Rain cap with insect screen	(optional)	PN: EC0-M9003011
• Inlet tube (0.8m, 1m, 1.5m, or 2m)	(optional)	PN: H02032X*
• Wall mounting bracket	(optional)	PN: H020005
• Roof Flange	(optional)	PN: ECO-M9003004
• Calibration Kit	(optional)	PN: H020331
• Service Kit	(optional)	PN: H020335
• Exhaust tube Kit	(optional)	PN: H020330
• External Pump Kit	(optional)	PN: H020332
• External Pump Controller	(optional)	PN: E011006
• External 12V Battery Cable	(optional)	PN: C020022

* X denotes either 1 (Green), 2 (Red) or 3 (Blue) for nephelometer or 0 (800ml insulated), 2 (1m un-insulated), 3 (1.5m un-insulated) or 4 (2m uninsulated) for sample inlet tube.

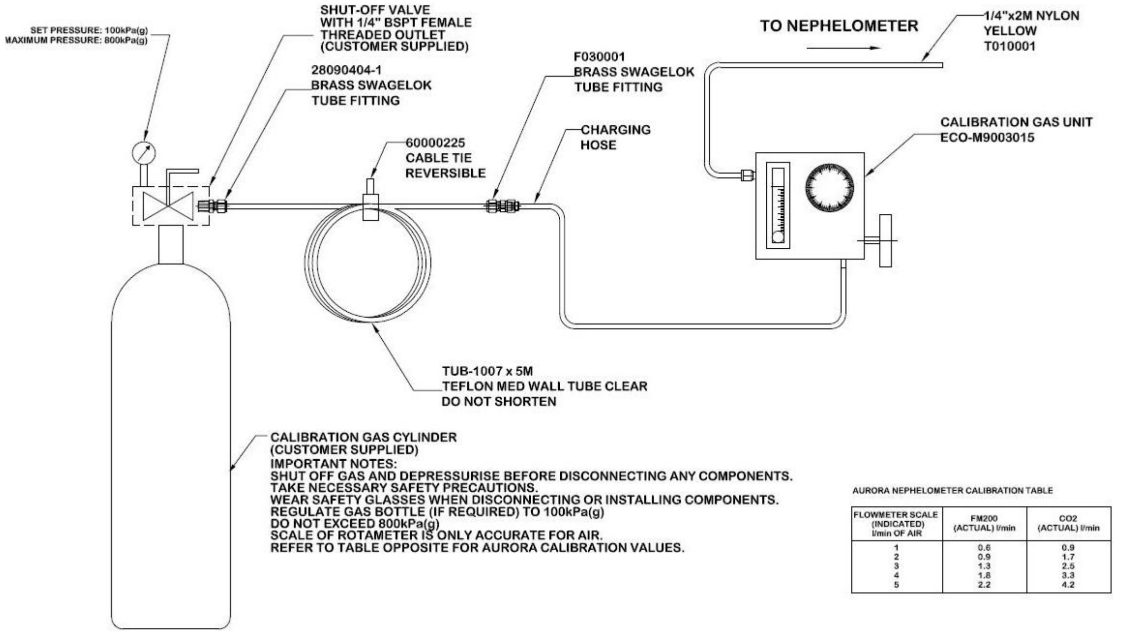
Note: Check that all these items have been delivered undamaged. If there is any items damaged or if you are unsure, please contact your supplier before turning on the instrument.

2.2 Assembly

2.2.1 Connecting the Calibration Gas

1. Consult your local regulations for the positioning of the gas cylinder.
2. In most cases the gas cylinders should be located outside the building and secured to a solid wall.
3. The Calibration gas should be high purity 99.99% gas for accurate calibration.
4. The calibration gas cylinder should be fitted with a regulator and flow meter.
5. It should also include at least 1 metre coiled metal line to bring gas temperature to room temperature, especially if a refrigerant gas is used.

Ecotech can supply an optional Calibration kit (H020331) which provides all the necessary connections to connect the gas cylinder to the Aurora. The recommended gas delivery system is shown in Figure 20.



FLOWMETER SCALE (INDICATED) l/min OF AIR	FM200 (ACTUAL) l/min	CO2 (ACTUAL) l/min
1	0.6	0.9
2	0.9	1.7
3	1.3	2.5
4	1.8	3.3
5	2.2	4.2

Figure 19 – Span gas plumbing installation

Connect your calibration gas to the span gas port on the side of the Aurora. No connection is required for the zero air as the Aurora has its own internal filters.

2.2.2 Connecting Power

CAUTION

The Aurora has an external, auto ranging power supply (100 to 250V AC, 50 or 60 Hz). This means that the Aurora can be connected to any domestic mains supply anywhere in the world via a standard IEC connector for the mains.

6. The power cord should be connected to a general purpose power outlet.
7. The outlet should have an earth pin for safety.
8. The output of the power supply is 12v DC. The power supply has a 4 pin connector to connect to the 12v in connector on the Aurora.
9. The on/off switch when pressed down will turn the nephelometer on.
10. There is a green indicator on the Power supply to show if the mains power is on or not.
11. It is also possible to power the Aurora from another 12V DC source such as a battery or solar panel system. To do this you need to purchase the External 12V Battery Cable.
    (PN: C020022, optional).
12. There is an internal fuse located on the power control board which is behind the sample heater. The cell needs to be removed to change this fuse.
13. The internal fuse is rated at: 5A T250V 20 x 5 mm.

2.2.3 External Cable Connections

Although the Aurora has its own internal data logging feature, some situations may require it to be connected to an external data logger. There are two ways to connect to a data logger:

RS232

Ecotech supply an RS232 cable with each Aurora nephelometer. This cable is suitable for connecting directly from the Aurora (Multi-drop port) to a standard 9 pin RS232 port found on most personal or laptop computers.

If you require a longer cable for your application, the following diagram shows how it can be made.

Note: When using cable lengths in excess of 3 meters, you may exceed the electromagnetic compatibility requirements for which this instrument has been tested. This could result in communication errors. You may need to reduce the Baud rate in order to reduce these errors.

Section 5 contains more information on setting up the RS232 communications for data logger.

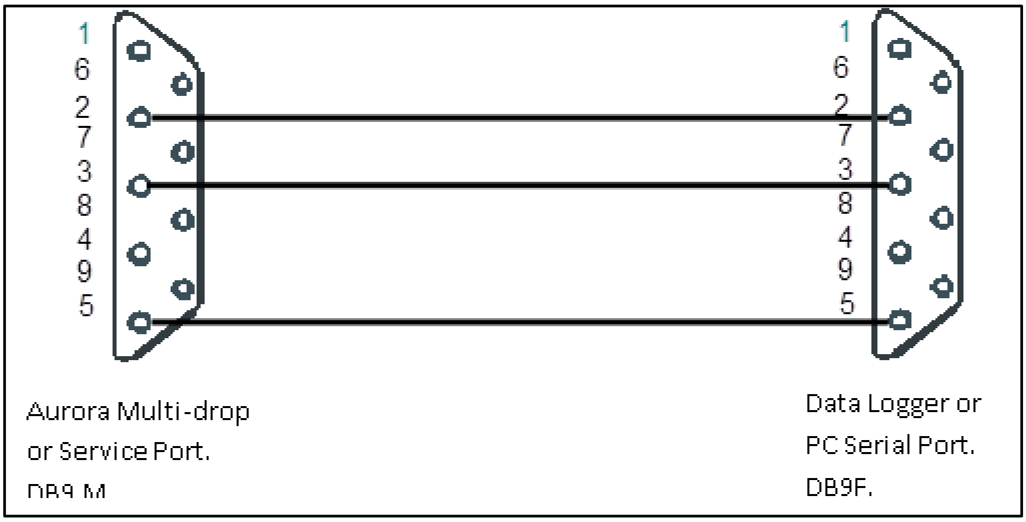


Figure 20 – Aurora service & multi-drop serial port cable

Table 3 – RS232 pins and their functions

Pin No	Function
1	CD (not used)
6	DSR (not used)
2	RD
7	RTS (not used)
3	TD
8	CTS (not used)
4	DTR (not used)
9	
5	GND
Shell	Chassis GND

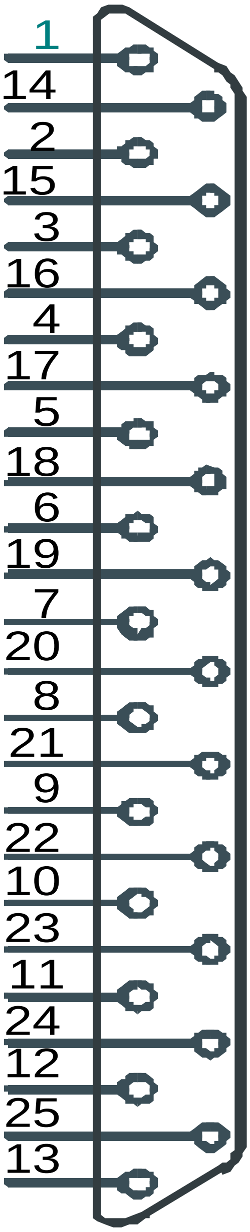
External I/O

The Aurora has 4 analog outputs for connecting to data loggers or chart recorders, which do not support RS232 communications. The External I/O connector has the following connections:

- 2 voltage outputs (0 to 5V) Vout1 & Vout2, as well as 2 current outputs (0 to 20mA or 4-20mA) Iout1 & Iout2.
- DOSPAN & DOZERO (contact closure inputs/open collector) for putting the nephelometer into SPAN or ZERO measure (not calibration).
- Calibration Mode digital output for indication when the Aurora is in a zero or span mode.

- +12V & +5V power supplies.
- Digital Analog & Chassis Grounds.

Table 4 – Aurora 1000 external I/O connector



For details in setting up the analog outputs, refer to section 5.4.

Pin No	Function
1	Chassis GND
14	Analog GND
2	Voltage OUT 1
15	Analog GND
3	Voltage OUT 2
16	Analog GND
4	Current OUT 1
17	Analog GND
5	Current OUT 2
18	Analog GND
6	
19	Digital GND
7	DOZERO
20	Digital GND
8	DOSPAN
21	Digital GND
9	+5V
22	Digital GND
10	Calibration mode
23	Digital GND
11	
24	Digital GND
12	+12V
25	+12V
13	Digital GND
Shell	Chassis GND

2.3 Mounting/Siting

Siting Considerations

For additional information regarding siting, please consult your local standards for siting guidelines.

The Australian Standard AS2922 requires that the sampling inlet be positioned:

- Between 2 and 5 metres above ground.
- At least one horizontal metre and one vertical metre from supporting structures or walls.
- With 120° of clear sky above the sampling inlet.
- With an unrestricted airflow of 270° around the inlet, or 180° if the inlet is on the side of a building.
- 20 metres from trees.
- With no boiler or incinerator flues nearby.

Mounting the Aurora

Note: The Aurora must be mounted so that the shortest possible length of tubing is used from nephelometer inlet to the sample inlet. This tubing should be as straight as possible with minimal kinks and bends as shown below.

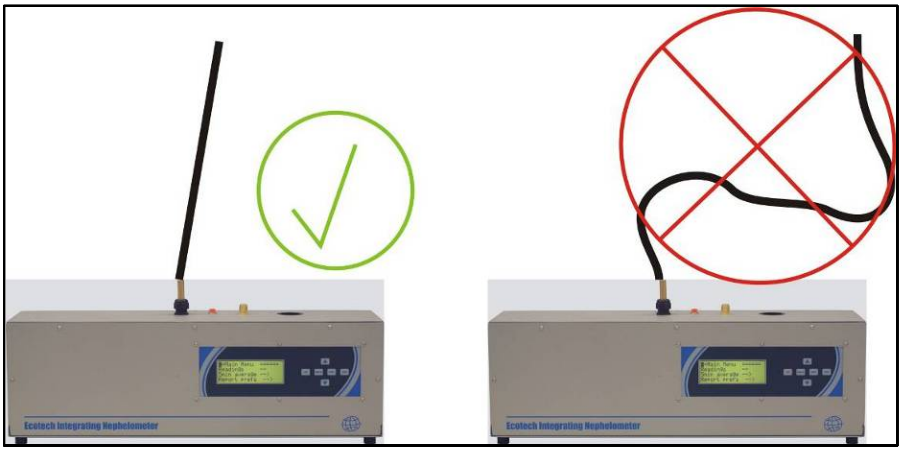


Figure 21 – Correct sample inlet connection

There are a number of ways in which the Aurora can be mounted. It can be seated on a bench top with the sample inlet running vertically through the roof, or mounted on a wall with the sample inlet running through the roof. An optional wall mounting bracket is available for easy mounting on the wall.

Attach the wall mounting bracket as follows:

1. Determine where the Aurora is to be located and draw the centre line on the wall. This determines the positions of the sample and calibration gas inlets. Extend this line to the roof.
2. Make sure there are no beams obstructing the inlets path through the roof.
3. Mark and drill the holes for the wall mounting bracket.
4. Secure the wall mounting bracket to the wall using two suitable fasteners. The bracket has two 7mm holes on its centre line to that effect. The two tabs should be at the bottom.
5. Mark the position of the hole for the sample inlet tube and drill.
6. The roof flange option can be used on the top of the roof to seal the sample inlet.

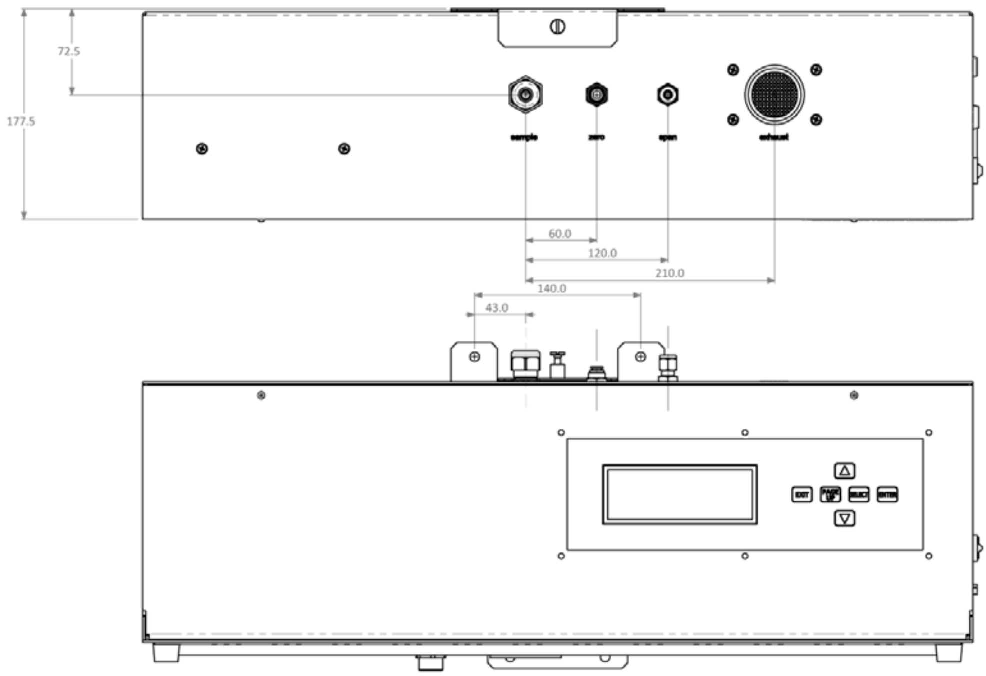


Figure 22 – Locations of pneumatic ports

Note: When drilling holes, be sure to cover all open ports on the Aurora and supplied tubing. This will reduce cell contamination.

2.4 Instrument Set-up

When setting up the Aurora the following actions should be performed:

1. Clear data logger (section 3.5.10).
2. Set correct time (section 3.5.9).
3. Set standard temperature (section 3.5.6 “Normalise to”).
4. Set filter (Kalman or Moving average) section 3.5.6.
5. Set automatic calibration interval (section 3.5.4.2 “Autocal intv”).
6. Set Calibration gas type (section 3.5.4.2 “span gas” and/or “custom span gas”).
7. Perform calibration (section 4.2).

3. Operation

With the Aurora 1000 installed correctly as outlined in the previous sections, it is now ready to be used. This section will discuss what to expect and how to configure the Aurora once it is powered up.

3.1 Start-up

When the power switch shown in Figure 18 is switched to the ON position, the Aurora will go through its start-up sequence as follows:

Welcome Screen

- The shutter solenoid will periodically click in and out of position every 30 seconds.
- The display backlight will light up.
- The Welcome screen will provide information about the Aurora and its wavelength.

```
   Ecotech Aurora 1000
         525nm
      Integrating
      Nephelometer
```

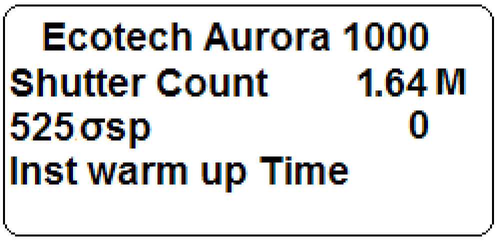
Instrument Check

The nephelometer runs through a diagnostic check of its systems checking the light source, environmental sensors and photomultiplier. If any of these components fails the test it will be displayed with a fail on the right side of the display.

```
  Ecotech Aurora 1000
Light Src chk      Pass
Env Sensor chk     Pass
PMT  chk           Pass
```

Warm-up

- The system calibration will commence.
- The nephelometer begins measuring the shutter count, allowing one minute for the light source to stabilise.



Main Screen

- After the system calibration is completed, the sample pump will start-up.
- The screen will now display the main screen.
- The Aurora is now in MONITOR STATE and is sampling as described in section 3.3.

3.2 General Operational Information

3.2.1 Display Panel & Keypad

The display panel and keypad (Figure 23) allows all current measurements to be displayed, settings to be entered and commands given. It consists of a 4 line LCD screen with 6 general use command keys/buttons.

Figure 23 – Display panel & keypad

Up arrow key (⮝) Moves the cursor to the previous menu item or, in an input field, moves the cursor to the previous choice or increments the digit in a numerical field.

Down arrow key (⮟) Moves the cursor to the next menu item or, in an input field, moves the cursor to the next choice or decrements the digit in a numerical field.

Select Selects the menu choice or selects the field for input.

Pg Up Moves the cursor to the previous page or screen.

Exit Leaves a field without making a change or returns the cursor to the main screen.

Enter Confirms a menu item or a field selection to the microprocessor.

Note: Only four lines may be displayed at a time. To reach options not on the screen, use the up and down arrow. Units displayed on screen are set within the **report prefs** submenu (section 3.5.6) with the exception of σ_{sp}, which always has units of Mm^{-1} (inverse megametres) and relative humidity, always in %.

3.2.2 Display Backlight

When the Aurora is initially turned on, the Backlight on the LCD display will also turn on. However if the keypad is not used for approximately 3 minutes, then the Backlight will turn off automatically. The display backlight can be re-activated by pressing any one of the keys on the keypad.

3.2.3 Display Adjustment

On power-up the display contrast will maintain the setting from its previous operation. The contrast can be adjusted by pressing either the up or down arrows on the keypad when on the main screen.

3.2.4 Navigating the Menu System

1. Press the up arrow and down arrow to move the cursor amongst menu options.
2. Press “Select” or “Enter” to activate a submenu or to perform an operation (these menu entries usually have → after them to indicate their type), or to edit a parameter. If the parameter is not editable then pressing “Select” or “Enter” will have no effect.
3. Press “Page up” to return to the next highest level menu.
4. Press “Exit” to return to the Information Screen.

3.2.5 Editing Parameters

1. Press the up arrow and down arrow to cycle among the options for that parameter.
2. Numerical parameters are usually entered digit by digit. Press the up arrow and down arrow to cycle among the options for that digit (including the decimal point). Press “Select” to move to the next digit to the right or Page up to move to the next digit to the left.
3. Press “Enter” to save changes to the parameter.
4. Press Exit to cancel changes to the parameter.

3.2.6 Obtaining Readings

The nephelometer readings may be obtained through any of the following methods:

- Display panel (refer to section 3.2.1).
- Internal Data Logging (refer to section 5.1).
- Serial RS232 Communication Ports (refer to section 5.3).
- Analogue outputs (refer to section 5.4).

3.3 Main Screen

The main screen is displayed after the Aurora has passed through its warm-up or after pressing Exit while navigating the menu system. This screen is divided into three sections.

1. The first line shows the Aurora's wavelength and the σ_{sp} current reading (updated each second).
2. The second line is the current system state line which will display information about the nephelometers performance including warnings of any faults within the nephelometer. If there are no system failures, then the line will be blank.
3. The last two lines display the current sample temperature (ST°C), Relative Humidity (RH%) and Barometric Pressure (BP). The value of each of these parameters is displayed immediately below on the fourth line.

The third line alternates after 16 seconds from the parameter names to the date and time. The date and time are only shown for 6 seconds.

525nm	σsp	7.235Mm^{-1}
ST°C	RH%	BP
32.0	19	1003.9

Figure 24 – Main screen

3.4 Sampling

The Aurora 1000 performs continuous real-time sampling. The Aurora will provide updated measurements every second. Some parameters are stored in the internal data logger of which the sampling time period can be chosen by the user (section 3.5.10 "Log period").

The parameters internally logged are:

σ_{sp}: Scattering coefficient (0 to 20,000Mm^{-1}).

ST: Sample air temperature in the cell (-20°C to 80°C).

ET: Temperature within the Enclosure (-40°C to 60°C).

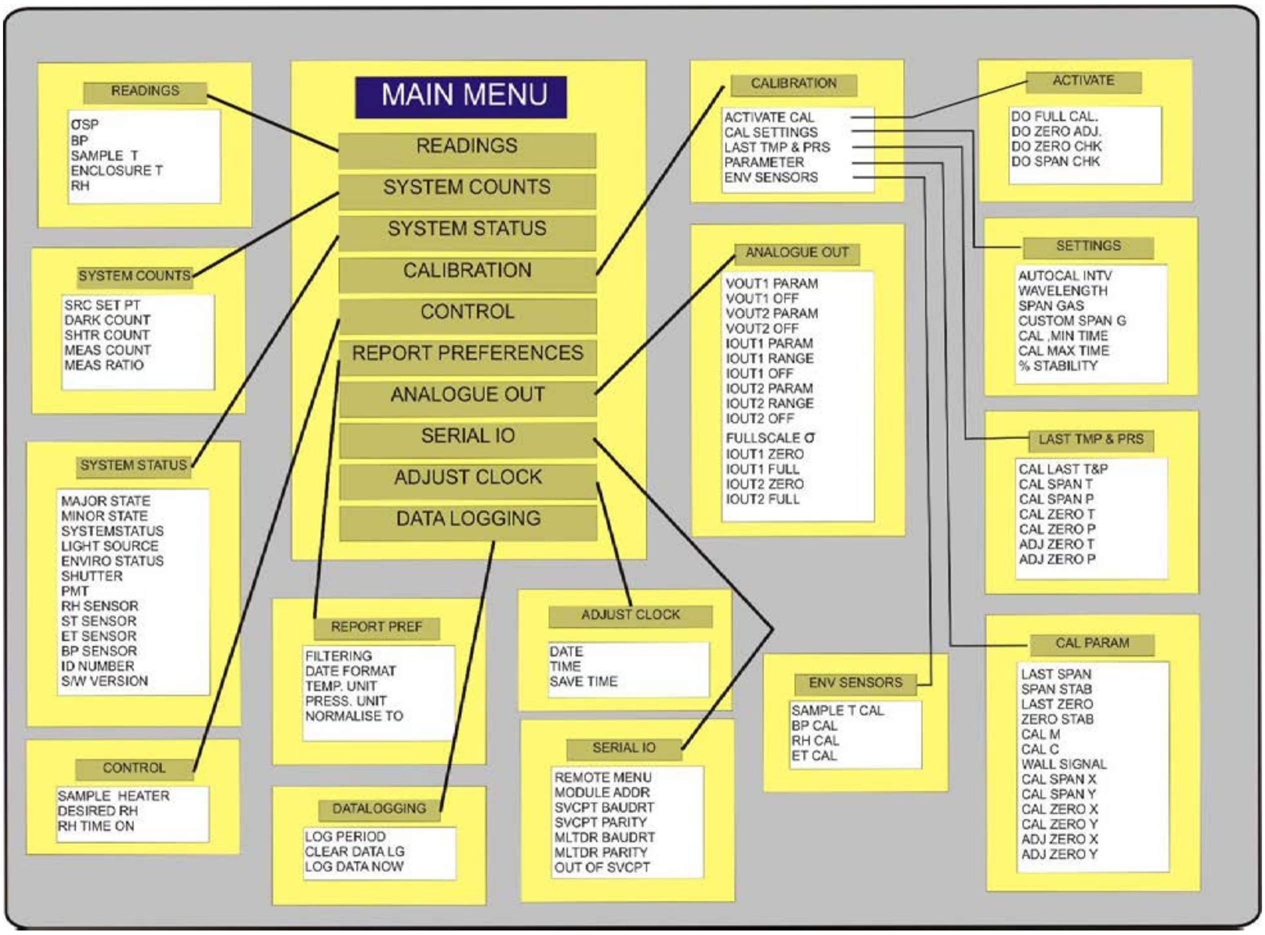
RH: Sample air relative humidity (0% to 100%).

BPs: Barometric pressure in the cell (150 to 1150 mbar).

3.5 Menus & Screens

To enter the Main **Menu** from the Information Screen press "Enter" or "Select". The Main **Menu** gives access to the following submenus.

Figure 25 – Menu system tree



3.5.1 Readings

The **Readings Submenu** displays the current environmental sensor readings. The σ_{sp} reading is updated more frequently than the other parameters.

σsp

Displays the current particulate scattering coefficient in Mm^{-1}

BP

Displays the current air pressure inside the cell (mBar or atm).

Sample T

Displays the current sample air temperature inside the cell (^{o}C or ^{o}K).

Enclosure T

Displays the current cell temperature (^{o}C or ^{o}K).

RH

Displays the current sample air relative humidity (%).

3.5.2 System Counts

Src Set PT

The Source set point is a setting for the intensity of older type light sources. In the Aurora 1000, this parameter is factory set to 0 as it is not used.

Dark Count

The measurement count taken when the light source is off, and is used as a background measurement of incident light. Readings of 0 through 200 are typical but can go as much as 500 in higher temperatures (refer to section 1.4.2 for more details).

SHTR Count

The shutter count measurement is takeen while the reference shutter is closed. This figure should be between 0.8M and 1.6M (refer to section 1.4.2 for more details).

Measure Count

The measurement taken with light source on and the reference shutter open. This figure will vary from 5k to 500k depending on particulate concentration (refer to section 1.4.2 for more details).

Measure Ratio

The measure ratio is the ratio between the measure count and shutter count. (refer to section 1.4.2 for more details).

3.5.3 System Status

Major States

Monitor: Normal monitoring mode

SysCal: System calibration mode (during start-up or reset)

SpnCal: Span calibration mode (during full calibration)

ZroCal: Zero calibration mode (during full calibration)

ZroChk: Zero check mode

SpnChk: Span check mode

LeaChk: Performing a leak check

ZroAdj: Zero offset adjust (manual or automatic offset adjustment)

Minor States

Normal: Normal Monitoring

ShtrDn: Shutter moving into position and stabilising

ShtrMs: Shutter in place, taking shutter measurement

ShtrUp: Shutter moving out of the way and stabilising

System Status

The System Status is the overall nephelometer status. If one status below fails then the system status will fail indicating that the entire system is not working.

Light Source

This status indicates whether the light source is working (pass/fail).

Enviro Status

The Enviro Status is the overall status of all the environmental sensors (RH Sensor, ST sensor, ET Sensor and BP Sensor). If one environmental sensor status fails then the Enviro Status will.

Shutter

This status indicates whether the shutter is working (pass/fail).

Photomultiplier

This status indicates whether the photomultiplier is working (pass/fail).

RH Sensor

This status indicates whether the Relative Humidity sensor is working (pass/fail).

ST Sensor

This status indicates whether the Sample Temperature sensor is working (pass/fail).

ET Sensor

This status indicates whether the Enclosure Temperature sensor is working (pass/fail).

BP Sensor

This status indicates whether the Pressure sensor is working (pass/fail).

ID Number

Lists the ID number of this unit.

S/W Version

This menu item displays the version of software that the instrument is currently running. This is useful during some diagnostic and fault finding checks as well as for finding if an update to the software is required.

3.5.4 Calibration

The Calibration submenu has 5 submenus which cover all the aspects of calibration. These submenus allow the user to set the correct parameters to perform a calibration, initiate a calibration sequence and view the results from the previous calibration. For more information on performing calibrations, refer to section X4X.

3.5.4.1 Activate Cal

Do full cal

Performs a two point calibration using calibration gas and zero air. This sequence will adjust the calibration curve. The results are recorded as Last span ck & Last zero ck.

Do zero adj

Performs a zero adjustment on the nephelometer using zero air.

The results are recorded as Last zero adj.

Do zero chk

Performs a check but no adjustment of the nephelometer’s zero using zero air. The results are recorded as Last zero ck.

Do span chk

Performs a check but no adjustment of nephelometer’s span using calibration gas. The results are recorded as Last span ck.

3.5.4.2 Cal Settings

AutoCal Intv

Sets the automatic calibration type (see next) repeat period: Hourly, 3hrs, 6hrs, 12hrs, 24hrs, Weekly on a designated day or Off.

Span gas

Sets the span gas to the type to be used during a full calibration: CO_2, SF6, FM-200, R-12, R 22, R-134 or Custom.

Custom SpanG

If the span gas type Custom is selected above, then the Rayleigh multiplier is entered here for the type of gas you are using (refer to Table 2).

Cal min time

Sets the minimum time (in minutes) that any span or zero adjustment or check may take.

Cal max time

Sets the maximum time (in minutes) that any span or zero adjustment or check may take.

% Stability

Sets the target stability for any span or zero adjustment or check.

Refer to sections 1.4.3 for further details.

3.5.4.3 Last TMP & PRS

Cal Span T

Displays the temperature during the last span calibration.

Cal Span P

Displays the pressure during the last span calibration.

Cal Zero T

Displays the temperature during the last zero calibration.

Cal Zero P

Displays the pressure during the last zero calibration.

Adj Zero T

Displays the temperature during the last zero adjustment.

Adj Zero P

Displays the pressure during the last zero adjustment.

3.5.4.4 Cal PARAMS

Last span

Displays the σ_{sp} value (in Mm^{-1}) obtained after a span check. If a full calibration is performed, it will display the last σ_{sp} value before the span adjustment was made.

Span stab

Displays the % stability achieved during a span check or full calibration.

Last zero

Displays the σ_{sp} value (in Mm^{-1}) obtained after a zero check. If a zero adjust is performed, it will display the last σ_{sp} value before the adjustment was made.

Zero stab

Displays the % stability achieved during a zero check or zero adjust.

Calibration M

Displays the gradient of the calibration line.

Calibration C

Displays the intercept of the calibration line.

Wall signal

Displays the calculated % of scattering as a result of wall scattering. This value is only updated after a full calibration or zero adjust is completed. Refer to section 1.4.3 for more details.

Cal SPAN X

Displays the extinction coefficient at span calibration point.

Cal SPAN Y

Displays the measurement ratio at span calibration point

Cal ZERO X

Displays the extinction coefficient at zero calibration point

Cal ZERO Y

Displays the measurement ratio at zero calibration point

Adj ZERO X

Displays the extinction coefficient at zero adjustment point

Adj ZERO Y

Displays the measurement ratio at zero adjustment point

3.5.4.5 Env Sensors

The **Environmental Sensors Menu** will display a screen:

* Warning * Changes will re-calibrate environmental sensors immediately.

By scrolling down you can find the four environmental sensors readings. To calibrate these sensors all that must be done is to enter in the correct value, the correct value must be obtained from a calibrated temperature, humidity or pressure sensor (refer to sections 4.4.1 and 4.4.2).

Sample T Cal
Displays the current temperature within the sample cell, field is editable.

BP Cal
Displays the current barometric pressure within the sample cell, field is editable.

RH Cal
Displays the current relative humidity within the sample cell, field is editable.

ET Cal
Displays the current temperature within the enclosure, field is editable.

Note: Do not change any of the above fields unless you are confident that the figure being entered is correct. Inaccurate figures will result in faulty readings.

3.5.5 Control

The **Control Submenu** is where the user can set the sample heater properties. The configuration of this menu will depend on the application of the nephelometer.

Sample Heater

Sets the sample heater to either enabled (RH or XX°C) or disabled (No).

If enabled (RH) the heater will maintain the sample air RH at a level less than that set in the Desired RH field (below).

The heater can also be enabled by choosing a temperature at which the heater will maintain the sample at 0-50°C.

Note: Typically the heater cannot heat beyond 45°C at a room temperature of 25°C.

If the sample heater is disabled then the sample air will not be heated.

Desired RH

Sets the desired relative humidity range of the sample air: <40% (less than 40%), <50%,<60%,<70%,<80%,or <90%.

RH Time On

Time in seconds that the sample heater is turned on for RH or temperature control.

3.5.6 Report Preferences

The Report preferences submenu allows the user to set key reporting preferences that will alter the way the data is recorded in the internal data logger or via the RS232 interface.

Filtering

Sets the type of filtering used on the output data: Kalman (Adaptive digital filter, see section1.4.2), MovAvg (fixed 30 second moving average filter) or None.

Date Format

Sets the date reporting format: D/M/Y, M/D/Y or Y-M-D (where D=Day, M=Month, Y=Year).

Temp.Unit

Sets the temperature unit: °C, °F or K (degree Celsius, Fahrenheit or Kelvin).

Press.Unit

Sets the barometric pressure unit: mb or atm (millibar or atmosphere).

Normalise to

Sets the standard temperature to which to normalise σ_{sp} readings: 25°C, 20°C, 0°C or None (do not normalise).

Temperature normalisation is used as follows:

- European Union 20°C
- US EPA 25°C
- UK and Australia 0°C

Ensure correct temperature is used as this will modify the data readings. Refer to section 1.4.3 for an example of how the readings can vary depending on the normalisation temperature.

3.5.7 Analogue Out

The **Analogue Out Submenu** is where the user assigns parameters to each of the 4 analogue output ports on the External IO (25way) connector (Table 4). The range and analogue calibration parameters can also be set.

Vout 1 Param

Sets the output parameters to be signalled on Voltage Out 1 (pin2).

Range is 0 – 5v. Parameters are σ_{sp}, ST, ET, RH, BP, Zero, Full, σ_{sp}5m.

Vout 1 Off

Applies an offset to the voltage output. None (0%), 5% or 10%.

Vout 2 Param

Sets the output parameters to be signalled on Voltage Out 2 (pin3).

Range is 0 – 5v. Parameters are σ_{sp}, ST, ET, RH, BP, Zero, Full, σ_{sp}5m.

Vout 2 Off

Applies an offset to the voltage output. None (0%), 5% or 10%.

Iout 1 Param

Sets the output parameters to be signalled on Current Out 1 (pin4). Parameters are σ_{sp}, ST, ET, RH, BP, Zero, Full, σ_{sp}5m.

Iout 1 Range

Sets the output current range for Current out 1: 0-20mA or 4-20mA.

Iout 1 Off

Applies an offset to the current output. None (0%), 5% or 10%.

Iout 2 Param

Sets the output parameters to be signalled on Current Out 2 (pin5). Parameters are σ_{sp}, ST, ET, RH, BP, Zero, Full, σ_{sp}5m.

Iout 2 Range

Sets the output current range for Current out 2: 0-20mA or 4-20mA.

Iout 2 Off

Applies an offset to the current output. None (0%), 5% or 10%.

Full Scale σ

Sets the full scale range of the σ_{sp} parameter in M^{m-1} : 100, 200, 500, 1000, 2000 or 10000.

Iout1 Zero

Zero adjustment for Current Out 1. Units are in DAC counts. 8uA/count.

Iout1 Full

Full scale adjustment for Current Out 1. Units are in DAC counts. 8uA/count.

Iout2 Zero

Zero adjustment for Current Out 2. Units are in DAC counts. 8uA/count.

Iout2 Full

Full scale adjustment for Current Out 2. Units are in DAC counts. 8uA/count.

For more information on setting up the analog outputs, refer to section 5.4.1.

Use zero and full to calibrate the Analogue outputs. They can also be used for calibrating your data logger's analog inputs.

3.5.8 Serial IO

The **Serial IO Submenu** is where the user sets the parameters for the two RS232 serial ports (Multi-drop and Service ports, Figure 17).

Remote Menu

When the **Remote Menu** is enabled, the user can access the menu system via the RS232 Service port using an ASCII terminal program. The user can navigate the menu remotely using the "Up", "Down", "Left", "Right" arrow keys on the terminal.

Module Addr

Address for multi-drop RS232 port: 0-7

MltDr Baud Rt

Communication Baud rate for multi-drop RS232 port: 1200 - 38400

MltDr Parity

Parity setting for multi-drop RS232 port: None, Even, Odd

SvcPt BaudRt

Communication Baud rate for service port: 1200 - 38400

SvcPt Parity

Parity setting for service port: None, Even, OddSvcPort Mode

This field allows the user to choose how the Serial port will be used. The options are:

None: Serial port will not be used

Reading : Data will be sent through the Serial port in the time periods specified within the "Reading Output" field below

Menu: When enabled, the user can access the menu system using an ASCII terminal program. The user can navigate the menu remotely using the Up, Down, Left, Right arrow keys on the terminal.

Reading Output

Sends an unpolled data output string to the service port:	None, 1 sec, 5 sec, 10 sec or 60 sec.	See section 5.1.4.

3.5.9 Adjust Clock

Note: When adjusting the clock ensure all data is downloaded before any changes are made.

To enter the current date and time: set the current date, the current time and remember to press enter on the **Save time** menu to have the date and time recorded.

A message "Setting clock…" will appear on the display and then return to the information screen.

Date	06/10/2007	Sets the current date
Time	11:02:09	Sets the current time
Save time	→	Records the date and time entered above

Note: Clear the data logger after changing time (refer to section 3.5.10).

3.5.10 Data Logging

The data logging submenu allows the user to set the averaging period of the internal data logger as well as clearing the memory of the Aurora 1000.

Log Period

Sets the data logging averaging period. 1min or 5 min.

Clear DataLg

Clears all data stored in the data logging memory.

Log Data Now

Records instantaneous readings when "Enter" is pressed.

3.5.11 Leak Test

This screen will prompt the user to perform a leak check, select yes and follow the instructions on the screen and at the same time follow the procedure in section 6.3.6.

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4. Calibration

The Aurora 1000 requires regular calibration against a known calibration source. The Aurora can perform 3 different calibrations of the measurement system:

- Precision Check (section 4.1)
- Full Calibration (section 4.2)
- Auto Calibration (section 4.3)

The Aurora also needs calibrations performed on various other sensors.

- Pressure Calibration (section 4.4.1)
- Sample Temperature and Humidity Calibration (section 4.4.2)

Note: Before commencing any calibrations, make sure that the Aurora has been given 30 minutes to stabilise.

Refer to section 6.2 for advice on calibration intervals.

4.1 Precision Check

Precision checks should be performed on a regular basis (daily or weekly) using a calibration gas such as CO_2 (100% purity). The precision check is used to detect any drift in the nephelometer's calibration and includes a span check and a zero check, which can be used to determine what action is required (if any) after the precision check.

Note: A precision check does not alter the calibration curve.

Table 4 – Calibration check criteria

Daily/Weekly Check	Calibration Tolerance	Action Required
Zero Check	$\pm$2 Mm^{-}	Do zero adjust
Zero Check	$\pm$4 Mm^{-}	Invalidate data. Do zero adjust
Span Check	$\pm$1% of span point*	Do full calibration
Span Check	$\pm$5% of span point*	Invalidate data. Do full calibration

* If calibrating 525nm with FM200, ≈ 220 Mm^{-1} @ STP, then the ±5% limit would be ± 11 Mm^{-1}. The ±1% limit would be ± 2.2 Mm^{-1}.

4.1.1 Span Check

The Span Check uses span gas to perform a span calibration on the Aurora without adjusting the calibration curve (only a comparison).

The Span check can be initiated as follows:

1. From the **Calibration →Activate Cal Submenu** select the "Do span chk".
2. The following message will appear "Span check will commence within 30 seconds".
3. The span valve will open. Make sure the calibration gas is connected and flowing.
4. The nephelometer will return to the main screen and display "Cal Stability" & "Cal Time".
5. The span check will continue until:

- "Cal Time" has passed the "Cal min time" (refer to section 3.5.4.2).
- & "Cal Stability" has exceeded the "% Stability" set in the **Settings Submenu** (refer to section 3.5.4.2).
- Or if "% Stability" has not been reached, then the span check will continue until the Cal max time has elapsed (refer to section 3.5.4.2).

6. After the span check has finished, the Aurora will update the values for "Last span ck" and "Span ck stab" in the **Cal Param Submenu.**

4.1.2 Zero Check

The Zero Check uses internally filtered particle free air to perform a zero calibration check on the Aurora without adjusting the zero point (offset).

The zero check can be initiated as follows:

1. From the **Calibration → Activate Cal Submenu** select the "Do zero chk" command.
2. The following message will appear "Zero check will commence within 30 seconds".
3. Next the zero pump will turn on and the nephelometer will return to the main screen and display "Cal Stability" & "Cal Time".
4. The zero check will continue until:

- "Cal Time" has passed the "Cal min time" (refer to section 3.5.4.2).
- & "Cal Stability" has exceeded the "% Stability" set in the **Settings Submenu** (refer to section 3.5.4.2).
- Or if "% stability" has not been reached, then the zero check will continue until the "Cal max time" has elapsed (refer to section 3.5.4.2).

5. After the zero check has finished, the Aurora will update the values for "Last zero ck" and "Zero ck stab" in the **Cal Param Submenu.**

4.2 Full Calibration

The full calibration performs a two-point calibration on the Aurora. The span point uses calibration gas, the zero point use internally filtered particle free air. A full calibration is one in which both the span and zero points on the calibration curve will be modified. Due to the high stability of the Aurora this type of calibration only needs to be performed approximately every 3 months using calibration gas. Typically CO_2 or FM200 is used for the full calibration. A full calibration can be performed once the setup is completed.

Note: When performing a full calibration or zero adjust, make sure that the filtering parameter in the report references menu is set to Kalman.

4.2.1 Set-up

Make sure that the following options in the **Calibration Submenu** are set (see section 3.5.4) before commencing a calibration.

1. "Span Gas type": Set to the type of calibration gas you are using. Generally CO_2 or FM200.
2. "Cal min time". Set the minimum time (in minutes) required to complete each calibration step (span or zero). Typically set to 15 minutes for a good calibration.
3. "Cal max time". Set to the maximum time (in minutes) required to complete each calibration step (span or zero). Typically set to 20 minutes for a good calibration.
4. "% Stability". Set the target stability for the calibration. A value of about 95-97% is recommended. If after Cal min time the calibration has not reached the target stability then the calibration will continue until it reaches the target stability or Cal max time, whichever comes first. Refer to sections 1.4.3 for further details.
5. Make sure your calibration gas is connected correctly and the valves and regulators have been opened. Refer to section 2.2.1 for details on connecting the calibration gas to the Aurora.

Note: Set the calibration gas flow rate to typically 3-4 lpm to calibrate the Aurora 1000.

4.2.2 Procedure

1. From the **Calibration → Activate Cal** Submenu select the Do full cal command. Immediately the following message will appear on the display. "Full calibration will commence within 30 seconds" after this the span gas solenoid valve inside the Aurora will open and the Main screen will display the following parameters (alternating):

Current σ_{sp}: 23.86

The current σsp during the calibration. (based on the old calibration curve).

Cal Stability: 97.50

% Stability during the calibration.

Measure Ratio: 0.0138

The Measure Ratio during the calibration.

Cal Time: 00:07:45

The time the calibration has been running. (hh:mm:ss)

2. The span calibration portion of the full calibration sequence will end after:

- "Cal Time" has passed the "Cal min time" (section 3.5.4.2) & "Cal Stability" has exceeded the "% Stability" set in the **Settings Submenu** (section 3.5.4.2). OR
- If "% Stability" has not been reached, then the zero check will continue until the "Cal max time" has elapsed.

3. After the span calibration has finished, the Aurora will update the values for "Last span" and "Span stab" in the **Calibration Submenu** as well as other vital calibration data. It will then automatically close the span gas solenoid valve and turn on the zero air pump ready for the zero calibration portion of the full calibration sequence.
4. The zero calibration will proceed the same as the span calibration. The information screen will display "ZroCal" as the major state. The bottom line will also display "σ_{sp}", "Cal Stability", "Meas Ratio" & "Cal Time".
5. After the zero calibration has finished, the Aurora will update the values for "Last zero" and "Zero stab" in the **Calibration Submenu** as well as other vital zero data. It will then turn off the zero air pump and turn on the sample pump ready for sample measuring.
6. After the sample measuring has commenced, the new calibration curve will be applied to the σ_{sp} readings.
7. Be sure to close the calibration gas cylinder after use to prevent any leaking.

4.2.3 Zero Adjust

The Zero Adjust performs a single point zero calibration on the Aurora. Using internally filtered particle free air, the zero adjust will adjust the zero calibration point (or offset) of the nephelometer. Although a zero calibration is calibrating against air rayleigh (14.82 x 10^{-6} m @ STP), the Aurora sets this point to zero (0) after the calibration. The zero adjust can be initiated as follows:

1. From the **Calibration →, Activate Cal Submenu** select the "Do zero adj" command. Immediately the following message will appear on the display. "Zero adjustment will commence within 30 seconds" after this the zero pump will turn on and the information screen will be displayed.
2. In the same manner as the span calibration, the information screen will display "σ_{sp}", "Cal Stability", "Meas Ratio" & "Cal Time".
3. The zero adjust will end after the "Cal Time" has passed the "Cal min time" and "Cal Stability" has exceeded the "% Stability" set in the **Calibration Submenu.** If the "% Stability" has not yet been reached, then the zero adjust will continue until the Cal max time has elapsed.

1. After the zero adjust has finished, the Aurora will update the values for last zero adj and zero stab in the **Calibration → Parameters Submenu** as well as changing the zero offset on the calibration curve. It will then turn off the zero pump and turn on the sample pump ready for sample measuring.
2. After the sample measuring has commenced, the new calibration curve will be applied to the σ_{sp} readings.

4.3 Auto Calibration

The Aurora can be set to perform calibrations automatically at regular intervals. The check interval can be set in the **Calibration Submenu** (Refer to section 3.5.4) under the AutoCal Intv parameter. The calibration can be set to occur: hourly, 3, 6, and 12, 24hrs, on a specific day of the week or off. The Autocal Type can be set to: zero check, span check, zero & span check, or zero adjust (as discussed in section 4.1.1, 4.1.2 and 4.2.3).

Note: You cannot perform a full calibration automatically.

4.4 Sensor Calibration

Equipment Required

- Calibrated Temperature Probe.
- Calibrated Relative Humidity Sensor or Psychrometer.
- Calibrated Barometric Pressure Sensor.

4.4.1 Pressure Calibration

1. Disconnect the sample pump and allow the pressure reading to stabilise.
2. Obtain the current barometric pressure reading from a Calibrated Barometric Pressure Sensor (BPS).
3. Enter the **Calibration → Env Sensors Menu,** scroll down until "BP Cal" field.
4. Enter the Barometric pressure reading obtained with BPS into the field and press enter.
5. Wait for the Barometric pressure reading to stablise and then compare with the BPS. Repeat if necessary.
6. Reconnect the sample pump.

4.4.2 Sample Temperature & Humidity Calibration

1. Open the Aurora front panel by removing the two thumb screws at the top.
2. Remove the Sample Air Temperature sensor from the cell by first removing the cable (unscrew nut 1 anti-clockwise)
3. Release the sensor by unscrewing nut 2 (anti-clockwise) as shown below and pull out.

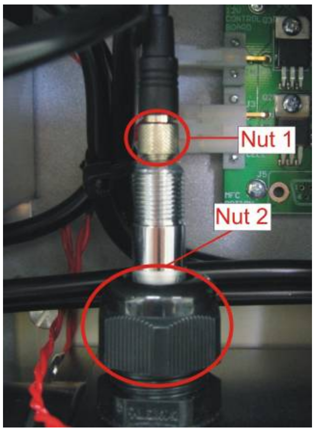


Figure 26 – Temperature/humidity sensor

4. Replace the nut 1 cable and allow the Aurora Air temp and Humidity readings to stabilise.
5. Place a calibrated Temperature and Humidity Probe close to the Air Temperature Sensor and allow them to stabilise to ambient room temperature/humidity. Then take an ambient reading.
6. Record the Temperature and humidity.
7. Enter the **Calibration → Env Sensors Menu**, scroll down and enter readings into their respective fields Temperature = Sample T Cal , Humidity = RH Cal.

Note: Perform span and zero calibration after environmental sensor calibration.

4.5 Calibration via External IO/RS232

4.5.1 Initiating a Calibration via the External IO

The Aurora has a 25 pin External IO connector which is used, not only for connecting the analogue outputs, but also for connecting digital inputs. There are two designated digital inputs used for initiating the Zero and Span Measure modes. These inputs are ideally suited for external data logging devices which control the calibration sequences. There are no menu settings or software setup required to activate these inputs, just hardware. See section 2.2.3 for wiring details to the External IO connector.

Activating Digital Inputs

The external inputs for the span and zero measure control require a contact closure or open collector type of input as shown in Figure 26. The span or zero measure will commence once either of the two pins on the External IO connector are closed or activated low (connected to ground).

The input signal must be:

Low (on) < 0.8V, or High (off) 2-5V

CAUTION
Do not exceed 5V dc on the pins of this connector.

These pins have been labelled DOZERO and DOSPAN as shown in Figure 25.

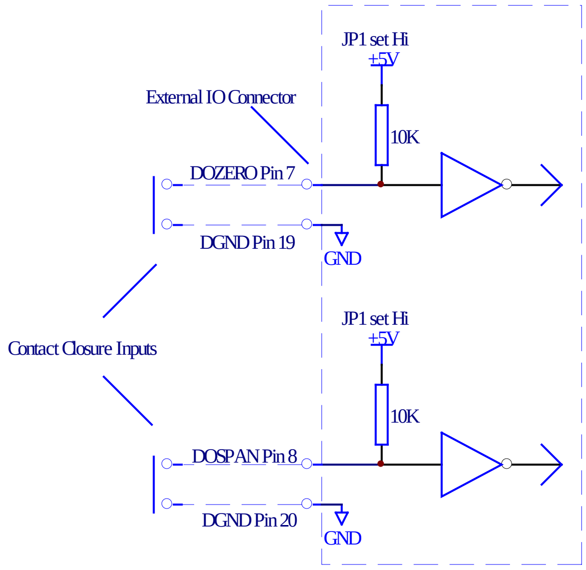


Figure 27 – External span & zero control

Zero Measure

The Zero Measure mode is activated using the DOZERO digital input.

1. As soon as the DOZERO input is activated the nephelometer will go into zero measure mode. The sample pump will turn off and the zero pump will turn on and zero valve will open, pumping particle free zero air into the measurement cell.
2. During the Zero Measure, the main screen will display “Zero Measure” on the top line.
3. The Zero Measure will continue for as long as the DOZERO input is activated. As soon as this input is de-activated, the Zero Measure will stop by turning off the zero pump, turning on the sample pump and switching of the zero valve. This procedure is only a check, no adjustment is made to the calibration curve.

Span Measure

The Span Measure mode is activated using the DOSPAN digital input.

1. As soon as the DOSPAN input is activated the nephelometer will go into Span measure mode. The sample pump will turn off and span gas solenoid valve will open, allowing calibration gas to pass into the measurement cell.
2. During the Span Measure, the main screen will display “Span Measure” on the top line.
3. The Span Measure will continue for as long as the DOSPAN input is activated. As soon as this input is de-activated, the Span Measure will stop by closing the span gas solenoid valve and turning on the sample pump. No adjustment is made to the calibration curve.

4.5.2 Initiating a Calibration via the RS232 Interface

The following commands can be used to initiate a calibration via the multi-drop serial port: (The multi-drop address is 0 in this example).

DO0001<CR> Sets the Aurora 1000 into span measure.

DO0000<CR> Sets the Aurora 1000 back to sample measure.

DO0011<CR> Sets the Aurora 1000 into zero measure.

DO0010<CR> Sets the Aurora 1000 back to sample measure.

Refer to Appendix A Aurora Command Set for more details on these commands and others.

4.6 Calibration Gases/Standards

4.6.1 Zero Air

The Aurora requires particle free air as its source of zero air. This is generated internally using the zero pump and a series of filters to remove all particulate matter. There is no need for any external connections to the zero air port. The zero point on the Aurora is also called Air Rayleigh which is equal to 14.82 x 10^{-6} m @ STP, however the measured σ_{sp} will read zero (0) at this point. All other measurements are made relative to Air Rayleigh.

4.6.2 Span Gas

The unique advantage of calibration (span) gases used in nephelometers is that they are stored in their liquefied form. Hence there is no need for expensive gas dilution systems. The calibration gas can be connected directly to the Aurora as specified in section 2.2.1. The other advantage is that each gas type has a unique σ_{sp} relative to Air Rayleigh. Hence the user when calibrating only has to select the correct span gas type and does not have to calculate dilution ratios and concentrations.

The Aurora supports CO_2, SF6, FM-200, R-12, R 22 and R-134 as the span gas types. See section 1.4.3 for further details on calibration gas constants for these gases. There is also the option of entering the Rayleigh multiplier of an unlisted calibration gas (or Custom Gas) in the **Calibration Menu.**

Ecotech use CO_2 and FM-200 when calibrating the Aurora in the factory. FM200 is a trade name and may also be known as Heptafluoropropane, CF_3CHFCF_3, HFC-227ea.

It is best to check with your local regulations and standards to see which calibration gas is to best used in your location.

CAUTION
While these calibration gases are not toxic or flammable, care should be taken to ensure proper installation and cylinder handling. Inhalation can cause irritations and even unconsciousness.

4.6.3 Australian Calibration Standard (AS3580.12.1:2.2001)

The Australian Standard AS3580 Method 12.1 for Determination of light scattering – Integrating Nephelometer method, mentions the requirements for calibration frequency.

In section 8.3 of the standard, it mentions “A span calibration using FM200 shall be conducted at minimum intervals of no more than 3 months when the nephelometer uses an internal calibration flag”. It also mentions that the “calibration check shall be done daily or at least weekly using the internal calibration flag”.

The Aurora 1000 meets these requirements using its own internal reference shutter. The reference shutter is the same as the calibration flag in that it exhibits a known output each time it is switched into the optical path. The main advantage with the Aurora reference shutter is that it automatically makes the reference shutter measurement every 30 seconds.

5. Downloading Data

There are three main ways of recording data from the Aurora 1000 which are mentioned in this manual. These are:

- Internal Data Logging Facility.
- External Data Logging using RS232 interfaces.
- External Data Logging using Analog Output interface.

Note: A laptop computer is a practical way of downloading data from a nephelometer in the field. If your laptop does not have a serial port, then a USB serial adaptor should be used. We recommend the easysync USB adaptor as it has been widely tested with all Ecotech products and works effectively. This can be purchased from Ecotech.

5.1 RS232 Interface

There are two RS232 interface connections available on the Aurora. They can be used for such things as downloading historical data, retrieving instantaneous readings or controlling certain features of the nephelometer. The following section will discuss the various functions of the Multi-drop Port and the Service Port.

5.1.1 Multi-drop Port

The multi-drop serial port is the main port used for external data logging and control. This port responds to the majority of RS232 commands. The term multi-drop is a term used to denote a parallel connection of multiple RS232 devices. All receivers share the same receive line that comes from a single master computer. Likewise, these multiple devices share the same transmit line which goes back to a single master computer.

This method is ideal for attaching multiple nephelometers to a single master computer where the number of available serial ports are limited. All the nephelometers can be connected to a single multi-drop cable. This type of configuration is often referred to as a daisy chain.

The integrity of this method relies on a number of important rules being followed:

1. Each instrument in the multi-drop must have a unique Module Address that is programmed into the unit before attaching to multi-drop cable.
2. After a command is sent by the master, the master must then wait for a response. Only after a reasonable time-out period should the master send another command.
3. The multi-drop master must include a time-out mechanism in the event that the Module Address sent with the command is garbled.
4. The master must correlate the unit response with the Module Address sent in the command to know which unit in the multi-drop is responding.

1. Any command that would cause two units on the multi-drop to respond at the same time must be avoided. If more than one unit attempts to respond on the common transmit line, a "data collision" will occur destroying both messages.

5.1.2 Service Port

The service serial port is not a multi-drop port and will not respond to any multi-drop commands. It is primarily used for factory testing, remote menu operation and unpolled data output.

5.1.3 Establishing Communications

The first step in establishing communications with the Aurora-is to connect a computer or terminal to the Multi-drop RS232 port. The default serial configuration for serial port is 9600,8,N,1 (9600 baud, 8 bits, no parity, and one stop bit). If you need to change the serial configuration from the default, use the **Serial IO Submenu.** Also make sure that the Module address is set to a unique value (the default is “0”).

Once the nephelometer has been connected, use a communication package such as Hyper Terminal to establish communications with the nephelometer. Use one of the commands mentioned in Appendix A to test the communications.

5.1.4 Unpolled

The unpolled data output mode allows the Aurora to send a string of data out to the Service port only. The data is transmitted from the Aurora at regular interval without having to receive any commands from an external device such as a data logger. This is useful for capturing RS232 data if you don’t have a data logging system.

The data can be captured using a communications package such as HyperTerminal. The data output can only be enabled from the Serial IO menu in section 3.5.8. The output data interval can be set between 1 and 60 seconds. The unpolled data output on the service port does not interfere with the operation of the Multidrop port.

The format of the output data is the same as the response of the VI099 command and is documented in Appendix A Aurora Command Set.

5.1.5 Remote Control

The remote control feature of the Aurora allows the user to remotely operate the Aurora menu system using a RS232 terminal program such as HyperTerminal, which is connected directly to the Service port only.

It can be enabled in two ways:

- From the **Remote Menu** in section 3.5.8.
- From the Multi-drop port using the `**M` command. See Appendix A Aurora Command Set.

The following key strokes can be used to navigate the **Remote Menu System.**

Table 5 – Keypad controls

Aurora 1000 Keypad	Terminal Equivalent
Enter	Enter
Select	Right Arrow Key
Page up	Left Arrow Key
*Exit	Q
Up arrow	Up Arrow Key
Down arrow	Down Arrow Key

Note: There may be a delay in returning to the main information screen as the remote terminal has to wait for the screen to be updated.

5.2 Internal Data Logging

5.2.1 Configuration

The internal Data Logging capabilities of the Aurora are very simple to operate. As long as the nephelometer is operating, the data logger is recording the data. The user has only to select the averaging period from the **Data Logging Menu** (section 3.5.10). These are:

- 5 minutes, this allows up to 61days of data storage.
- 1 minute, this allows up to 12 days of data storage.

The data logger memory is cyclic, so that once it is full it will rewrite over the earliest data records. The memory is also battery backed so that data will not be lost when the power is off.

The data logger memory should be reset at the start of a sampling episode. When data is downloaded, it will only be taken from that time onwards.

The Log Data Now function allows the user to manually test the data logger by recording data instantaneously when the “Enter” key is pressed.

The parameters recorded in the data logger are as follows and cannot be changed:

Date Time, Averaging, σ_{sp} ($m10^{-6}$), Air Temp(°C), Cell Temp (°C), RH (%), Pressure (mbar)e.g. 23/03/2004 12:30:00,5 min average,27.81,21.92,22.33,44.67,1009.77

5.2.2 Data Downloader Software

With the Aurora Data Downloader installed on your computer, the internal data logged by the Aurora can easily be downloaded to a text file where it can then be imported into a spread sheet program such as Excel.

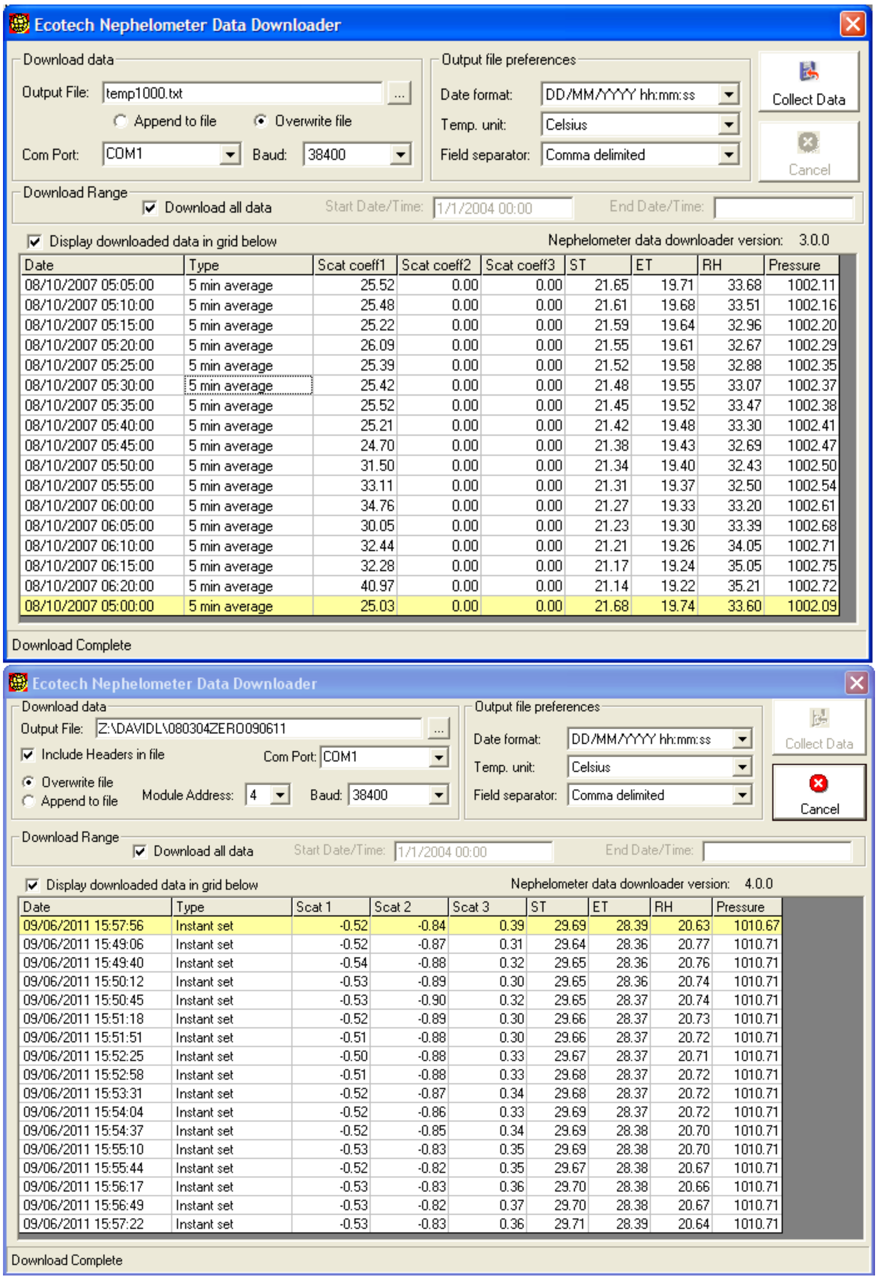


Figure 28 – Aurora data downloader

1. Open the Aurora Data Downloader software where the following window is displayed as in Figure 26. The bottom left hand corner of the window displays the current status.
2. Ensure that the Aurora is connected directly to your computer via the Multi-drop port and your computer's serial port.
3. Enter in the "Output File" the name of the file you wish to save data to, and select whether you wish to overwrite or append to the file, if it already exists. Click the "…" button to browse for your output file. For importing into Excel, we recommend using the "csv" file extension for your output file.
4. Select the appropriate Com port to be used by your computer.
5. Set the Baud rate in the Data Downloader to match the setting on the Multi-drop port on your Aurora **(Serial IO Menu).**

Note: We recommend using a baud rate of 38400 for fast downloading speed.

6. Select the appropriate Date Format, Temperature Unit and Field Separator. These settings will affect the format of the downloaded file. The Date Format is important if you're going to be importing the downloaded data into a spread sheet such as Excel.
7. Select either the "download all data" box or enter the start and end date for the period of data you wish to download.
8. Select the box labelled "Display downloaded data in grid below" if you want to see the data as it is collected. For some computers, this option may slow down the data collection rate.
9. When all is ready, click the "Collect Data" button. You will see the window below fill up with data. The data will also be saved to the file.
10. When downloading is complete, you will be asked whether you wish to clear the data store. If you collect data periodically, it's recommended that you clear the data each time, so you won't have to download the same data over and over again.

Figure 29 – Clear the data store window

11. If the Aurora is not connected or the serial IO settings are not correct, an error will be displayed when you try to collect data.

5.2.3 Importing Data into MS. Excel

Note: If your data has been stored in a text file with a CSV suffix, then Excel will automatically assign the data to individual columns.

1. To import your data into Excel, run Excel and select File > Open. Then choose to open files of type "Text files", and select your data file.

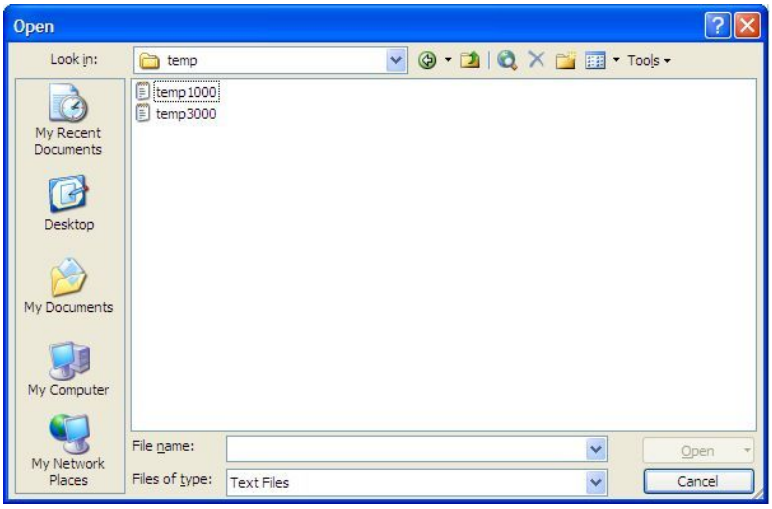


Figure 30 – Open window

2. The Text Import Wizard will appear.
3. Set the settings to Delimited. Press the "Next" button.

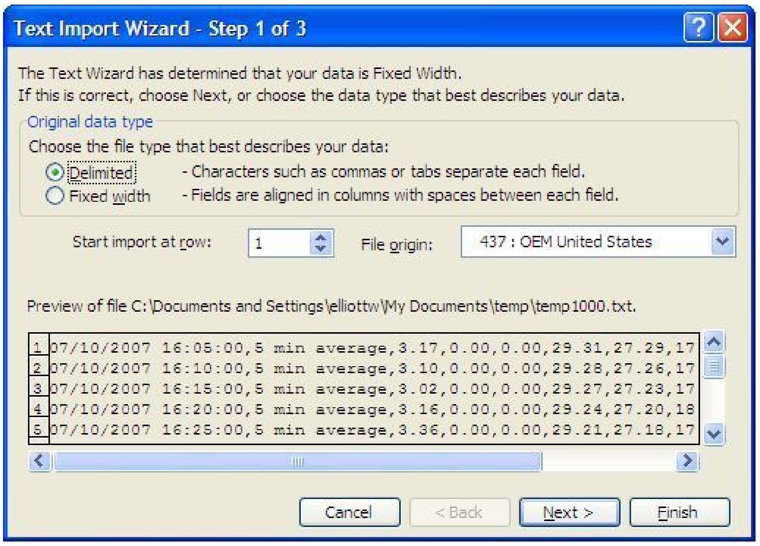


Figure 31 – Step 1

4. Include Comma and Tab as the delimiters for the data. Press the “Next” button.

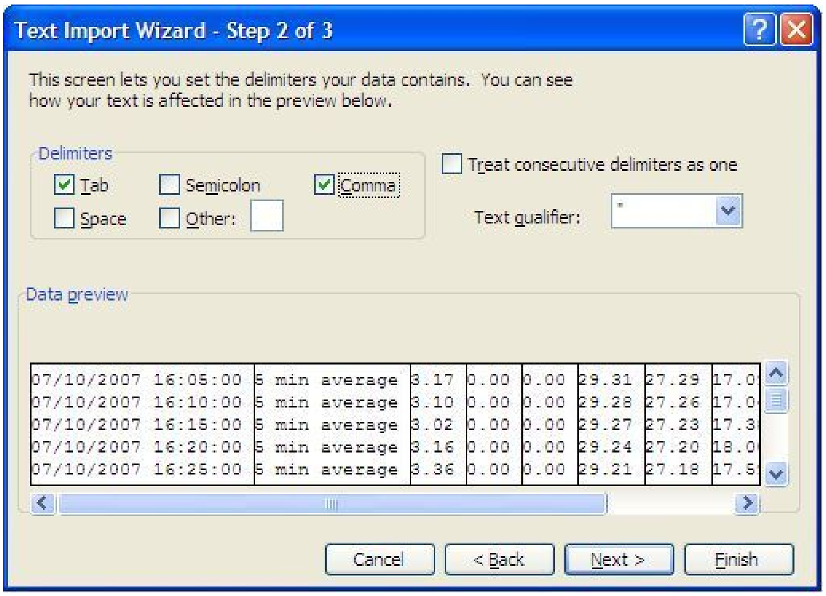
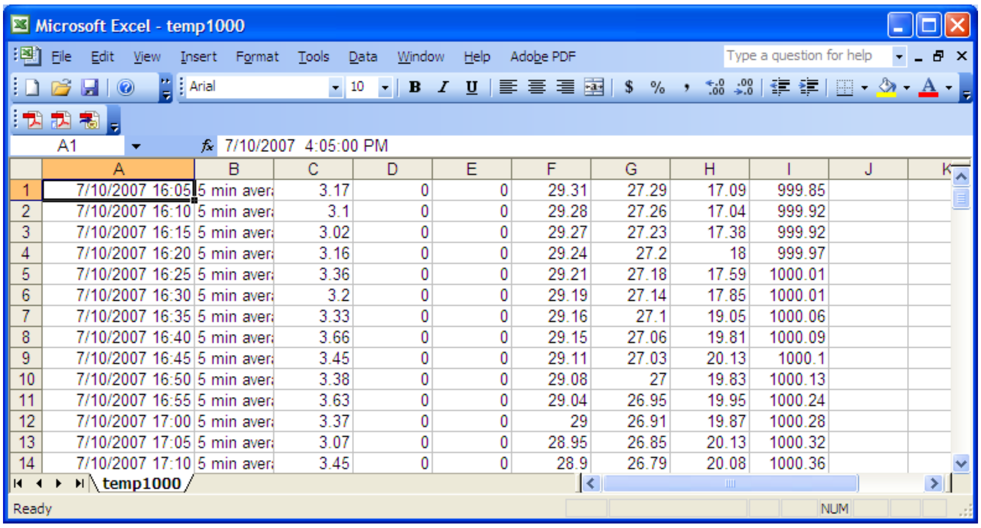


Figure 32 – Step 2

5. Set the first row to Date format.
6. Press the “Finish” button.

Figure 33 – Step 3

7. Your data should be imported into Excel, as shown below in Figure 32.



	A	B	C	D	E	F	G	H	I	J	K
1	7/10/2007 16:05	5 min aver:	3.17	0	0	29.31	27.29	17.09	999.85		
2	7/10/2007 16:10	5 min aver:	3.1	0	0	29.28	27.26	17.04	999.92		
3	7/10/2007 16:15	5 min aver:	3.02	0	0	29.27	27.23	17.38	999.92		
4	7/10/2007 16:20	5 min aver:	3.16	0	0	29.24	27.2	18	999.97		
5	7/10/2007 16:25	5 min aver:	3.36	0	0	29.21	27.18	17.59	1000.01		
6	7/10/2007 16:30	5 min aver:	3.2	0	0	29.19	27.14	17.85	1000.01		
7	7/10/2007 16:35	5 min aver:	3.33	0	0	29.16	27.1	19.05	1000.06		
8	7/10/2007 16:40	5 min aver:	3.66	0	0	29.15	27.06	19.81	1000.09		
9	7/10/2007 16:45	5 min aver:	3.45	0	0	29.11	27.03	20.13	1000.1		
10	7/10/2007 16:50	5 min aver:	3.38	0	0	29.08	27	19.83	1000.13		
11	7/10/2007 16:55	5 min aver:	3.63	0	0	29.04	26.95	19.95	1000.24		
12	7/10/2007 17:00	5 min aver:	3.37	0	0	29	26.91	19.87	1000.28		
13	7/10/2007 17:05	5 min aver:	3.07	0	0	28.95	26.85	20.13	1000.32		
14	7/10/2007 17:10	5 min aver:	3.45	0	0	28.9	26.79	20.08	1000.36		

Figure 34 – Imported data

Note: If dates fail to import correctly, you may have to change your regional options. This can be done from the Control Panel > Regional Settings. In Control Panel > Regional and language options > Customise, you should make sure that the Decimal symbol is set to a Period "." Not a Comma",". This will make it easier to download comma separated variables.

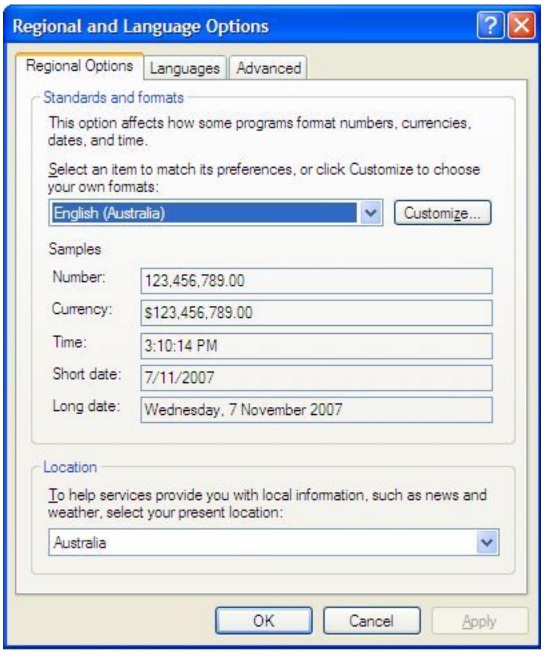


Figure 35 – Regional settings

5.3 External Data Logging

There are a number of ways connecting the Aurora 1000 to an external data logger. The best way is by using the RS232 interface as there is no degradation in the transfer of data. The Ecotech WinAQMS Data Acquisition System can be easily configured to log any of the Aurora parameters via RS232 Multi-drop communications.

Using WinAQMS

For details on connecting the Aurora to the WinAQMS Data Acquisition System, please refer to the WinAQMS manual.

Unpolled Data

For details on using an RS232 terminal program for capturing data from the Aurora, please refer to section 5.1.4.

Other Data Logging Software

If you are using some other data logging software for logging the Aurora 1000 then please refer carefully to the RS232 commands listed in Section 5 of this manual as to whether the software is compatible.

Note: Ecotech takes no responsibility for data integrity when the Aurora is used with third party software which does not meet the guidelines set out in the Appendix.

5.4 External Analog Data Logging

Another method of interfacing the Aurora 1000 to a data logger or chart recorder is by using the analog outputs. This is the next best option if there is no RS232 support.

5.4.1 Analogue Output Ports

The Aurora 1000 has 4 analog outputs. 2 x voltage and 2 x current outputs. These connections are found on the External I/O connector as shown in section 2.2.3.

- Vout1. Pin 2, 0 to 5V
- Vout2. Pin 3, 0 to 5V
- Iout1. Pin 4, 0 to 20mA or 4-20mA
- Iout2. Pin 5, 0 to 20mA or 4-20mA
- Ground. Pins 15, 16, 17, 18.

Any of the main parameters σ_{sp}, AirTemp, CelTemp, RH & Pressure can be assigned to any of these analog outputs. See section 2.2.3 for details on how to do this.

The following table lists some typical multipliers (M) and offsets (B) which would be used when programming your data logger or chart recorder.

Table 6 – Analog, multiplier and offsets

Parameter	Range	Voltage Output 0 – 5V		Current Output 0 – 20 mA		Current Output 4 – 20 mA	
		M	B	M	B	M	B
σ_{sp}*	0 – 2000 Mm^{-1}	400	0	100	0	125	-500
ST	-10°C to 60°C	20	-40	5	-40	6.25	-65
ET	-10°C to 60°C	20	-40	5	-40	6.25	-65
RH	0% to 98%	20	0	5	0	6.25	-25
BP	515 to 1115 mbar	120	+515	30	+515	37.55	+365
σ_{sp}5m *	0 – 2000 Mm^{-1}	400	0	100	0	125	-500

*0-2000Mm^{-1} is default setting, user can specify any range they wish.

Zero and Full are used to calibrate the Analogue outputs. They can also be used for calibrating your data logger.

Each of the analog outputs can also be assigned an offset of 0%, 5% or 10% so that a floating zero can be used if the situation requires it.

Current outputs can be converted to voltage outputs by connecting a terminating resistor of value between 100 & 250 ohms between the output pin and the ground pin. The above multipliers would have to be recalculated to suit the terminating resistor used.

5.4.2 Analogue Output Calibration

The two voltage outputs and the two current outputs mentioned above can be calibrated. The following procedure explains how the V_{out} and I_{out} can be calibrated using a digital voltmeter (DVM). The same procedure applies if a data logger or chart recorder is connected.

Voltage Output

1. Connect a calibrated DVM to the voltage output 1. The metre should be set to measure DC Volts.
2. In the **Analog Output Menu** set the V_{out} 1 param to: Full. Set the V_{out} 1 off to: NONE. The DVM should read an output of 4.5V.
3. If this reading is high or low (eg. 4.51V), then move down to the V_{out} 1 4.5V parameter and increase or decrease this number until the DVM reads 4.5V exactly.
4. Then set the V_{out} 1 param to: Zero. The DVM should read the low scale output of 0.5V.

5. If this reading is high or low (eg. 0.48V), then move down to the V_{out} 1 0.5V parameter and increase or decrease this number until the DVM reads 0.5V exactly.
6. Repeat steps 2 – 5 until the correct full scale and zero readings are obtained. Then set the V_{out} 1 param to the desired parameter for that channel and connect it to the data logger or chart recorder.
7. Verify that the data logger or chart recorder reading, correlate with what the Aurora is measuring.

The same procedure applies to the $V_{out\ 2}$ calibration.

Current Output

1. Connect a calibrated DVM to the current output. The meter should be set to measure mA and connected in series with the output. If you have a terminating resistor on the I_{out}, then you can measure the voltage across the resistor.
2. In the **Analog Output Menu** set the I_{out} 1 param to: Full. Set the I_{out} 1 range to: 4 –20 mA. Set the I_{out} 1 off to: None. The DVM should read the full scale output of 20mA.
3. If this reading is high or low (eg. 20.15mA), then move down to the I_{out} 1 Full parameter and increase or decrease this number until the DVM reads 20mA exactly.
4. Then set the I_{out} 1 param to: Zero. The DVM should read the zero scale output of 4mA.
5. If this reading is high or low (eg. 4.05mA), then move down to the I_{out} 1 Zero parameter and increase or decrease this number until the DVM reads 4mA exactly.
6. Repeat steps 2 – 5 until the correct full scale and zero readings are obtained. Then set the I_{out} 1 param to the desired parameter for that channel and connect it to the data logger or chart recorder.
7. Verify that the data logger or chart recorder reading, correlate with what the Aurora is measuring.
8. The same procedure applies to the I_{out} 2 calibration.

5.5 Upgrading Aurora 1000 Firmware

As improvements are made to the Aurora, these can be easily passed on to the user by updating the firmware (software operating within the Microprocessor board). To update the Aurora, you will need the Ecotech Firmware Updater Program. This is available on the Utilities CD supplied with your nephelometer or through the Ecotech website www.ecotech.com. Install this software on a Windows based computer with a COM port. Just follow the instructions on the installation screens to install this software.

The firmware file will have the ".sx" suffix. (eg. Aurora1000 V1.05.004.512K.SX). V1.05.004 refers to the version number. To check whether you have this version already installed on your nephelometer, check within the S**ystem Status Menu** (section 3.5.3).

To update the firmware on the Aurora 1000:

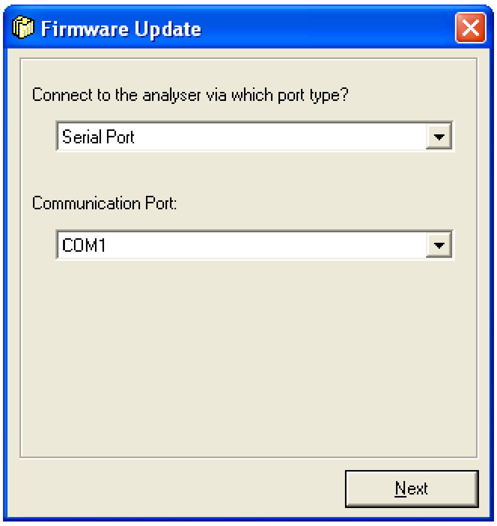


Figure 36 – Communications window

1. Run "Firmware Updater" from the Start - Programs - Ecotech - **Firmware Updater Menu.**
2. Connect the Aurora to the computer using a standard serial cable (you must connect directly to the Multi-drop port).
3. Select "Serial Port" and the COM Port on the computer from those listed on the Firmware Update screen as shown in Figure 35.
4. Press the "Next Button" to move to the next menu.

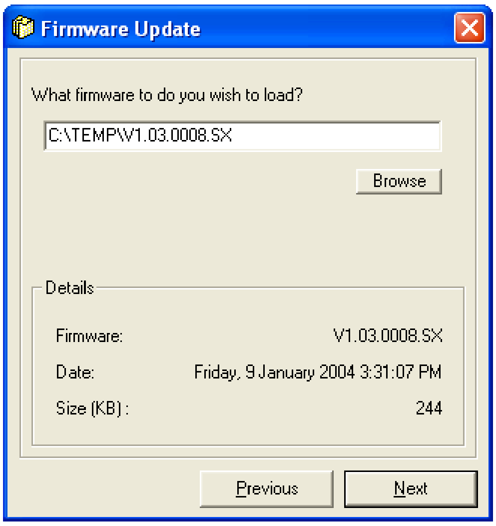


Figure 37 – File window

5. Using the "Browse" button, locate the firmware file (.sx) which you wish to update the Aurora with.
6. Verify its details in the Details window as shown in Figure 36.
7. Press the "Next" Button to move to the next menu.

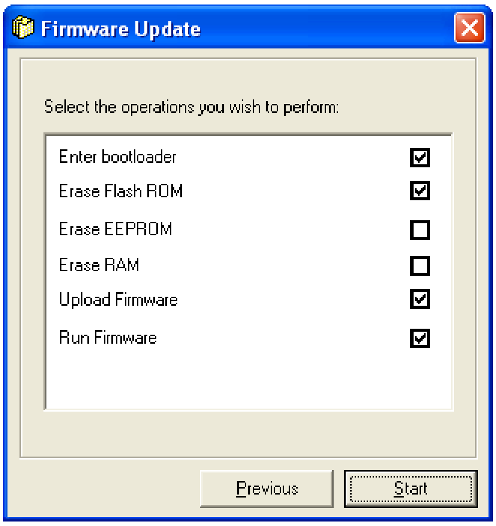


Figure 38 – Operations window

8. Turn off the Aurora, and connect it directly to your computer via the Multi-Drop port and your computer's serial port. There is no need to change any baud rates.
9. Make sure that all the boxes as shown in Figure 37 are checked.
10. Press the "Start" button.

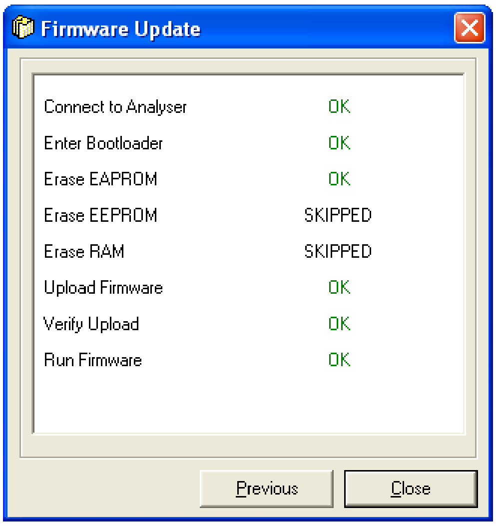


Figure 39 – Data transfer window

11. Turn on the Aurora 1000.
12. The Firmware Updater window will show each step as the firmware is uploaded. **Do not** turn the nephelometer off until the 'Close' button is enabled as shown in Figure 38.
13. Your Aurora should now be running with the updated firmware. Confirm this.

After the firmware update, it is recommended that you do the following:

1. Reset the Aurora by turning the power off then on again.
2. Reconnect any cables that may have been removed to perform the update.
3. Perform a full gas calibration.
4. Clear the Aurora’s data log.

The Aurora 1000 is now ready for use.

6. Maintenance

The following outlines a periodic maintenance schedule for the Aurora 1000. This schedule is based on experience under normal operating conditions, and may need to be modified to suit specific operating conditions. It is recommended that this schedule be followed in order to maintain reliable, long-term operation of the nephelometer.

6.1 Maintenance Tools

To perform general maintenance on the Aurora, the user will be required to carry the following equipment:

Equipment Required

- Phillips Head Screwdrivers.
- Flat ended Screwdriver.
- Adjustable wrench.
- Black cloth or plastic bag.

Consumables

Zero/Span Fine filter DFU (99.5%) pt: FIL-1050 (included in service kit H020335).

Service Kit (Optional)

The optional service kit (part number H020335) contains the following items. All of these parts may or may not be used in the 12 monthly maintenance depending on the condition of the nephelometer. O-Rings need only be changed if they look damaged or they are the cause of a leak.

Table 7 – Service kit

Item	Qty	Part Number	Description
1	1	FUS-1156	5A T250V Fuse
2	1	TUB-1015	Black Carbon Tubing 50mm
3	1	ZRU-22006361	V-Ring V10A for PMT
4	4	O010015	O-RING 1/4ID VITON for Cell End Nuts
5	1	25000420-2	O-RING for Light Source
6	4	ORI-1007	O-RING BS148 NITRILE for Cell Housing
7	2	B040008	AA Alkaline Batteries 1.5V
8	2	FIL-1050	DFU 99.5% for Zero/Span Fine filter and Zero Air Pump
9	1	C060002	Lint Free tissues, 5 Sheets

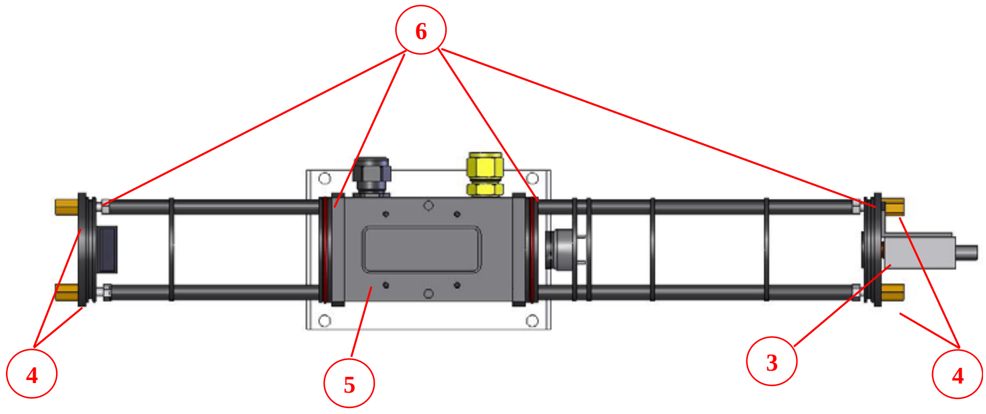


Figure 40 – Aurora 1000 O-ring locations

6.2 Maintenance Schedule

Table 8 – Maintenance schedule

Interval *	Item	Procedure	Page
Weekly	Precision Check	Check	Section 6.3.1
Quarterly	Sample inlet & Bug trap	Inspect/Clean	Section 6.3.3
	Full Calibration	Perform	Section 4.2
	Clock	Check	Section 3.5.9
6 Months	Zero Pump Inlet Filter	Inspect/Replace	Section 6.3.4
	Zero / Span Fine Filter	Inspect/Replace	Section 6.3.5
	Measurement Cell	Inspect/Clean	Section 6.3.2
	Leak Check	Perform	Section 6.3.6

Interval *	Item	Procedure	Page
Yearly	Zero Noise Check	Perform	Section 6.3.11
	Batteries[1]	Inspect/Replace	Section 6.3.7
	Optical Chamber	Inspect/ Clean	Section 6.3.9
	Pneumatics	Inspect/ Clean	Section 6.3.8
	Light Source[2]	Check/Adjust	Section 6.3.12

[1] It is recommended that the backup batteries are disconnected if the Aurora 1000 is to be powered down for more than a few months. Save the logged data before you remove the old batteries as the data will be lost.

*Suggested intervals for maintenance procedure may vary with sampling intensity and environmental conditions.

6.3 Maintenance Procedures

6.3.1 Precision Check

To ensure the nephelometer is running appropriately precision checks should be performed every week. A precision (calibration) check involves performing a span and zero calibration check (which may have been performed automatically over night or manually), then. entering the **Calibration Menu** and checking the “Last zero ck” field, “Zero ck stab” and “Last span ck” field.

1. The “Last zero ck” field should be 0 ±1 Mm^{-1}
2. The “Last span ck” field should be within ±5% of span value.
3. The “zero ck stab” and “span check stab” fields should be above that entered into the “stability field” within the **Calibration Menu.**

6.3.2 Measurement Cell Cleaning

As the nephelometer cell gets dirty, the wall signal will slowly increase with each calibration. A 5% change in wall signal is considered a good indication of when to clean the cell. It is a good to record the wall signal when it is first put into the field (or after cell cleaning) and then monitor the wall signal with each calibration. When the wall signal increases 5% above the initial value, it may be time to give the cell a clean. If this is part of the 6 monthly maintenance, the cell does not need to be removed.

If it is part of the 12 monthly maintenance, then follow the procedure in section 6.3.9 where the optical chamber is removed.

1. Turn off the nephelometer.
2. Undo the two screws located on the front panel of the nephelometer (1) and lower the Aurora front panel.
3. Unscrew the 4 screws holding the light source in place (2).
4. Unplug the cable connected to the right side of the light source (3).

Note: Ensure that the O-ring within the light source is not lost or misplaced.

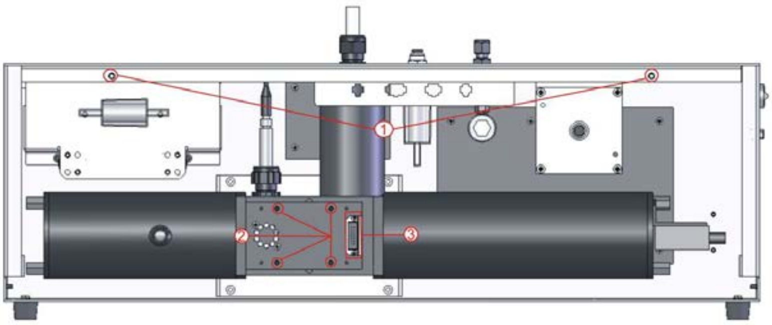


Figure 41 – Aurora internal components

5. Use warm water on a lint free tissue or cloth to wipe the insides of the cell paying special attention to the bottom right section and the walls.

Note: Do not leave fingerprints or any residue within the cell.

6. Leave the cell open until all internal surfaces are dry of water.
7. Carefully replace the light source, cables, and front panel of the nephelometer.
8. Always perform a leak check and full calibration after removing the light source.

6.3.3 Sample Inlet & Bug Trap Clean

1. Remove the insect trap from the inlet.
2. Turn the two white handles so that they are not holding the central filter in place (see Figure 40).

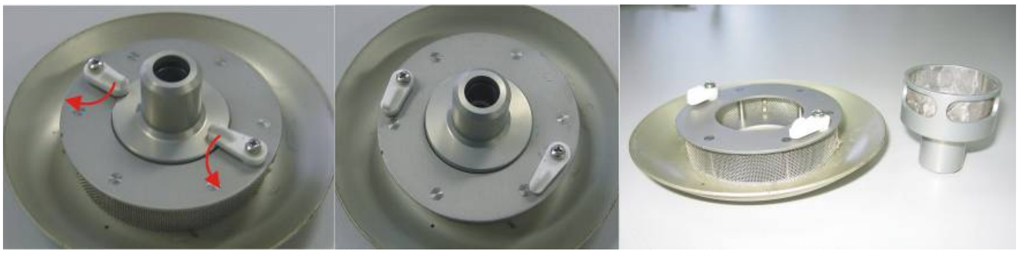


Figure 42 – Insect trap removal

3. Remove the central filter and clean both the inner and outer filters with warm water. Allow them to dry.
4. Place the inner filter back into the insect trap, return the handles to their original position and return the insect trap to the inlet.

6.3.4 Zero Pump Inlet Filter

1. Open front panel.
2. Remove DFU from the quick fit fitting and the clear tubing (Figure 41).
3. Replace with a new DFU 99.5% (pt: FIL-1050).
4. Close front panel.

Note: The six month interval is given as an indication only. More frequent filter replacements may be required depending on the nephelometer location.

6.3.5 Zero Span Fine Filter

1. Open front panel
2. Remove DFU from the clear tubing (Figure 41).
3. Replace with a new DFU 99.5% (pt: FIL-1050)
4. Close front panel.

Note: The six month interval is given as an indication only. More frequent filter replacements may be required depending on the nephelometer location.

6.3.6 Leak Check

1. Should be performed earlier than scheduled if a high zero reading is observed. (greater than 1Mm^{-1}). Should also be performed if any maintenance work has been conducted.
2. Open front panel (Section 6.3.2)
3. Disconnect the external sample tubing from main sample inlet (2).
4. Remove the black tubing from exhaust fan (1) and place it on main sample inlet (2) as shown in Figure 43.
5. Enter Leak check menu on Main menu, screen will prompt you to connect the exhaust to the inlet, once this is done (step 4) change leak check field to yes and press “Enter”.

6. Nephelometer will activate the zero pump and pressure will increase. Wait as nephelometer checks for a slow leak over 5 minutes.
7. If the screen gives the result “leak test a pass”, then there are no leaks and the tubes should be returned to normal.
8. If the leak test fails and “Low leak” is displayed then check that the tubing between the cell and sample inlet is not damaged or not plugged properly.
9. If the leak test fails and “Press.Leak” is displayed there is a leak within the cell (including tubing).

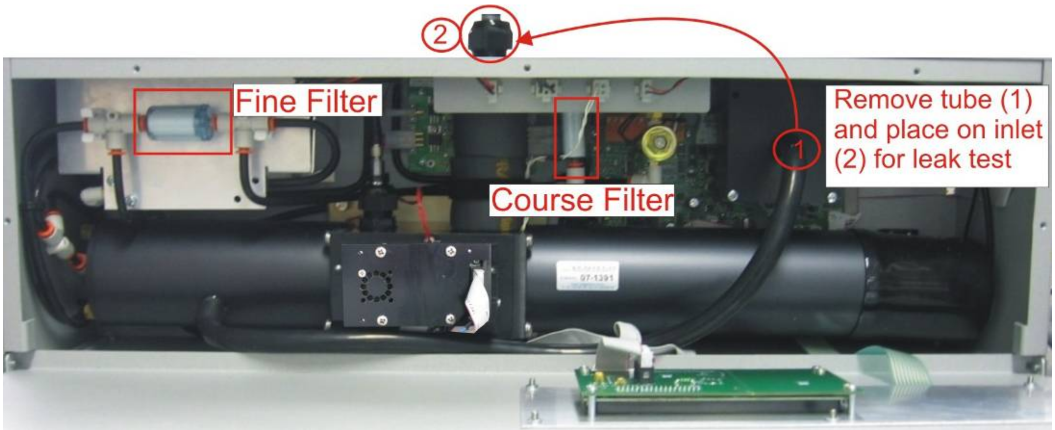


Figure 43 – Aurora with filters highlighted and leak test setup shown

6.3.7 Battery Replacement

Replace the two AA alkaline back-up batteries. This is best done with the power connected so that the clock and logged data are not lost.

Note: It is recommended that the backup batteries are removed if the Aurora is to be powered down for more than a few months. Save the logged data before you remove the old batteries as it will be lost.

6.3.8 Pneumatics Cleaning

This should be performed only when the optical chamber is removed from the nephelometer for cleaning. (refer to section 6.3.9).

1. Follow the procedure from section 6.3.9 to remove the optical chamber.
2. Remove black exhaust tubing from the exhaust fan (1) and the optical chamber (2) as shown in Figure 44.
3. Unscrew the black gland on top of the nephelometer (4).
4. Remove the sample heater from its connector (5) and gently pull the main inlet down until it is out.
5. Clean both the inlet and exhaust tubes in warm clean water (do not put the main inlet under water, only clean inside of tube). Do not use any solvents or chemicals for cleaning.
6. Leave to dry then replace all components back into nephelometer as they were found. This includes the optical chamber after it has been cleaned.

7. Perform a leak check and full calibration.

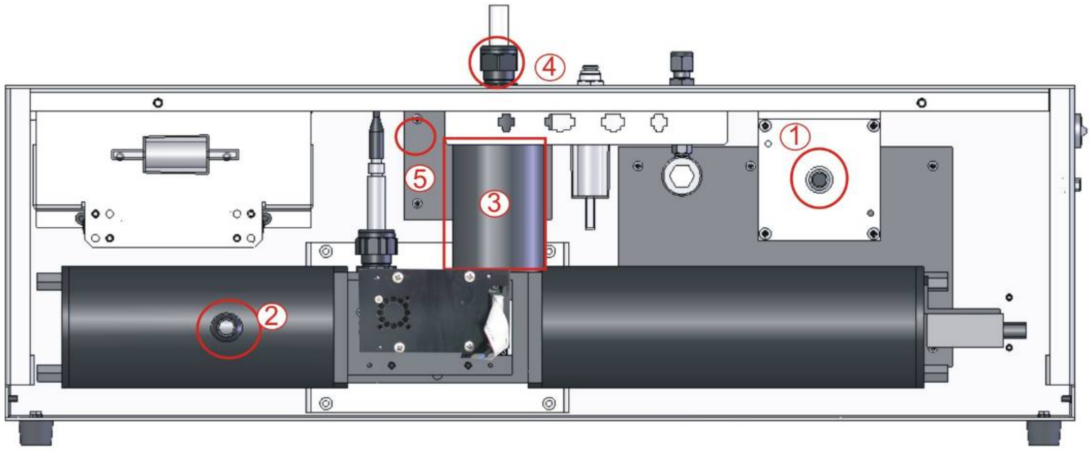


Figure 44 – Internal pneumatic tubing

6.3.9 Optical Chamber Cleaning

In order to clean all parts of the optical chamber, the optical chamber should be completely removed from the nephelometer. This procedure should also include the step for cleaning the Measurement cell as in section 6.3.2. Refer to Figure 44 above for component locations.

Optical Chamber Removal

1. Follow the steps (1 to 5) from section 6.3.2 to remove the light source
2. Remove the lower part of the inlet heater insulation by undoing the black Velcro strap (3). Velcro strap (3).
3. Using the adjustable wrench disconnect the sample inlet heater from the cell by turning the brass feral anti-clockwise. Use a second wrench to hold the bottom fitting.
4. Loosen the black cable gland (4) at the top of the inlet and pull it up so that it is clear of the measurement cell.
5. Disconnect the sample temperature sensor by turning the outer metal sleeve anti-clockwise and pull up.
6. Disconnect the two heater cables (5) on the power control board.
7. Disconnect the (white) reference shutter cable from the top panel connector.
8. Using a long flat screwdriver, unscrew the 4 captive screws at the base of the measurement cell mounting plate.
9. Remove the large black tube off the optical chamber exhaust port (2).
10. Disconnect the small black tube on the left hand end of the chamber.
11. With almost everything disconnected, carefully pull the optical chamber out and rest it on the front door with some bubble wrap under it to protect it.

12. Carefully pull back the large black rubber cap on the right hand end of the chamber. There are 2 cables and 1 small black tube penetrating this cap.

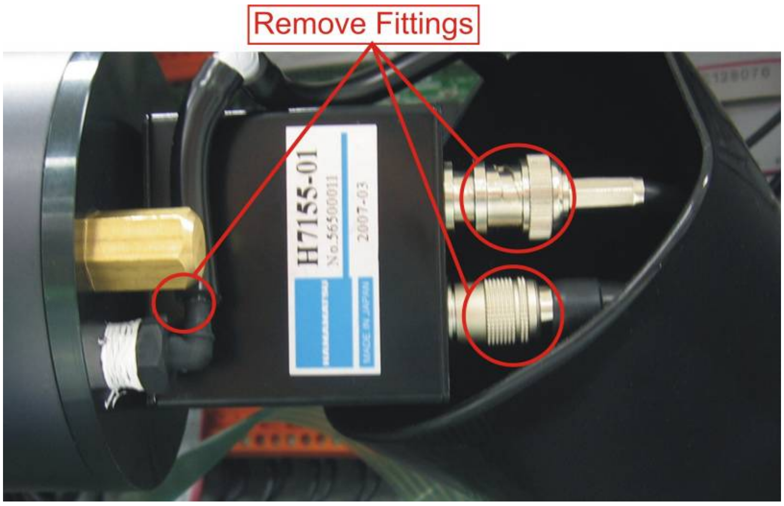


Figure 45 – Removal of cell fittings

13. Remove the black tubing from the port.
14. Disconnect the coaxial cable by rotating it anti-clockwise and pull.
15. Remove the other smaller cable by pulling back the outer metal ring, then pull.
16. Now the optical chamber should be completely free to move.

Cleaning Reference Shutter

1. Remove the 2 brass nuts at the PMT end of the chamber and do not lose the 2 small O-rings.
2. Remove the chamber end plate and PMT assembly by pulling it out. A small amount of wriggling will be required because of the O-ring seal. Cover the PMT to ensure that the PMT's exposure to light is minimised
3. Remove the chamber cylinder on the right side (PMT side) by carefully twisting and pulling it off. Try to avoid scratching the cylinder's walls.
4. Clean the top of the reference shutter glass (Figure 47) with a lint free tissue or cotton bud and warm clean water, then leave to dry. Also clean the opposite side of the reference shutter glass by spraying CO Contact cleaner into the small shutter aperture to flush out any debris. Check that the reference shutter adjustment screw in the side of the shutter plate is not loose.
5. If the baffles are dirty, clean them in a similar manner or by using compressed air.
6. Check the O-rings for cracks or dirt and clean if necessary. Avoid using O-ring grease.

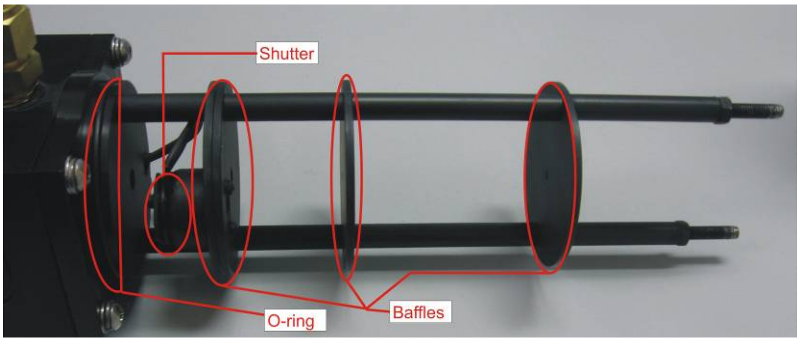


Figure 46 – Optical chamber right cylinder components

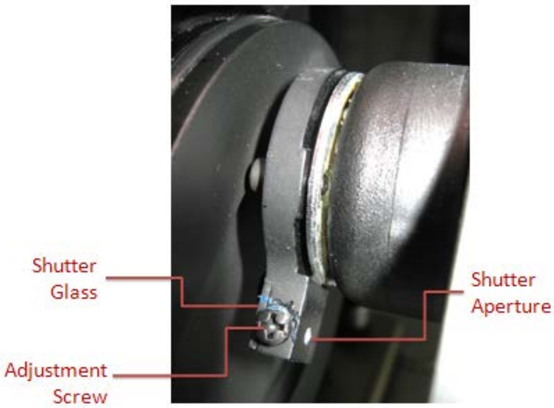


Figure 47 – Reference shutter

Cleaning Light Trap Mirror

1. Remove the 2 brass nuts at the left hand end of the chamber and do not lose the 2 small O-rings.
2. Remove the chamber end plate from the left end of the optical chamber cylinder (light trap) by pulling it away from centre. A small amount of wriggling will be required because of the O-ring seal.
3. Be very careful not to touch the mirror surface.
4. Slide the outer cylinder off making sure not to scratch the inside surface.

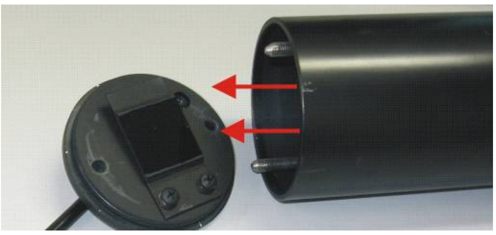


Figure 48 – Removing light trap

5. Inspect the light trap mirror surface using a very bright torch (eg LED type), and viewing it from various angles. Look for signs of white streaks or dust in the centre of the glass.

6. If the glass surface does need cleaning, use a precision electronic cleaning solvent which leaves no residue, low toxicity and has a CO_2 propellant (CRC CO Contact Cleaner).

CAUTION

Do not use Isopropanol (IPA).

7. Spray the electronic cleaning solvent on the surface of the glass, then quickly using a lint free tissue, remove the solvent in one continuous sweep covering the full width of the glass. Then re-inspect with a torch for no residue.
8. Surface dust can be cleaned by lightly blowing or using a horse hair camera lens cleaner.
9. If the baffles are dirty, clean them with a lint free tissue or cotton bud and warm clean water or by using compressed air, then leave to dry.
10. Check the O-rings for cracks or dirt and clean if necessary. Avoid using O-Ring grease.

Optical Chamber Replacement

1. With all parts of the chamber cleaned and dry, it is now time to replace the chamber back to its original position.
2. Slide the two cylinders back on the push the light trap end plate and PMT end plates on.
3. Tighten the 4 brass nuts and O-rings on each end to seal the optical chamber.
4. Now replace the optical chamber into the nephelometer and replace all connectors and pneumatic connections in reverse order to steps 1 to 16.
5. With everything connected, perform a leak check, then a full calibration before normal operations can begin.

6.3.10 PMT Replacement

This procedure is for replacing the Photo Multiplier Tube (PMT) in the Aurora. This is not part of the routine maintenance and should only be performed on the advice of Ecotech engineers. It should only be performed by qualified Ecotech personnel or suitably trained field technicians. Please read through this procedure first before commencing any work.

CAUTION

This procedure involves handling light sensitive equipment. Make sure that all power is off. Exposing the PMT to light when it’s on will cause irreversible damage to the PMT. Exposure to strong ambient light can also cause short term instability. Be sure to keep the PMT covered at all times.

Removing PMT

1. Follow the steps 1 to 16 from section 6.3.9 for removal of the optical chamber.

2. Now the PMT should be fully exposed.
3. The PMT is mounted on a bracket which is connected to the chamber end-plate with two M4 screws. Before removing this bracket, make sure you have ready a black bag or cloth to put the PMT in. Also, between the PMT and the cell end plate there is a small V-Ring O-ring which will fall out when the PMT is removed. Do not lose this O-ring.
4. Remove the PMT, O-ring and bracket and place in the black bag.
5. Now remove the PMT bracket from the PMT by unscrewing the 4 M3 screws. Each screw should have a spring washer, flat washer & white insulator. Please do not lose these.

Figure 49 – Removing the PMT

6. Before removing the PMT completely, note the orientation of the PMT in relation to the optical chamber and bracket.

Installing New PMT

1. Now take the new PMT from its box. Remove its protective black cover from its window and place it on the old PMT.

Figure 50 – New PMT inserted

2. Then screw the new PMT onto the PMT bracket with the 4 M3 screws.
3. Attach the PMT bracket to the cell end plate and make sure the V-ring is re-inserted flat and its sides are not twisted.
4. Reconnect the 2 cables and push the black tubing in firmly.
5. Replace the black rubber cap making sure there are no gaps around the optical chamber.
6. Return the assembled optical chamber to the nephelometer in the reverse order to which it was removed.
7. Double check all connections before turning the unit on.

Restarting the Nephelometer

1. After turning on the power, observe the dark count. It should be stable and typically less than 100. Check for further light leaks by turning off the room lighting and looking for a decrease in dark count.
2. In the **System Counts Menu,** check that the shutter counts and measure counts are all within their limits. (shutter count 0.8M to 1.6M, measure count greater than 6 - 10K)
3. When you are confident that everything is good, perform a leak check, then close the front panel.
4. Allow the Aurora to warm up for at least 10 minutes, and then perform a full calibration.
5. After the calibration, verify that the ambient readings are realistic and stable.
6. Return the faulty PMT to Ecotech.

6.3.11 Zero Noise Test

Calculating the zero noise is the best way to confirm the operational performance of the Aurora 1000 Nephelometer. The following procedure explains how to do this:

1. Operate the Aurora 1000 at room temperature for at least 30 minutes before starting the test.

2. Set the Aurora 1000 into zero calibration mode for a period of 2 hours. This can be done by using either of the following three methods:
   a. In the **Calibration Menu**, set the minimum calibration time to 120 minutes, and the maximum calibration time to 121 minutes, then set it to do a zero check.
   b. On the 25pin external IO connector, connect pin 7 (DO ZERO) to pin 20 (Digital GND) to put it in zero mode.
   c. Connect an external Disposable Filter Unit (DFU) to the sample inlet during normal sampling mode.
3. In the **Data Logging Menu,** set the "Log Period" to 1. minute.
4. Clear the Data Log memory. (be sure you have downloaded any previously logged data that you may need).
5. Allow the Aurora 1000 to continue running on zero air for a period of 120 minutes (2 hours), uninterrupted.
6. When the 2 hours are complete, connect the Aurora 1000 to a PC using the RS232 cable and use the installed Aurora Data Downloader software to download the 2 hours of zero data to the PC. See section 5.2 to do this.
7. Using MS Excel, import the data into a new spread sheet.
8. For the scattering data use the STDEV() command in Excel to calculated the Standard Deviation of the zero data over the 2 hour period.
9. This calculated standard deviation is the zero noise value for that particular nephelometer.
10. If the zero noise is less than 0.15Mm^{-1}, then the nephelometer is considered to be in good working order.

If the nephelometer zero noise is above 0.15Mm^{-1}, then this could be due to a number of factors including:

- Pneumatic leak in the cell or plumbing.
- Light leak near the PMT.
- Dirty measurement cell or optical chamber.
- Low intensity light source.
- Dirty light trap mirror.
- Noisy PMT.
- Loose or dirty reference shutter.

6.3.12 Light Source Check

The performance of the light source can be verified without having to remove the light source from the measurement cell. The following procedures are simple checks which can be done. Ultimately calculating the zero noise is the best way to confirm the overall operational performance of the Aurora 1000 Nephelometer. Refer to section 6.3.11.

Performance Verification

1. Visually inspect the operation of the light source by looking down the sample inlet tube. You will see the Red, Green or Blue light source flashing inside the cell depending on the wavelength of the nephelometer.
2. Enter the first **Hidden Menu** by pressing the “hidden key” which is located directly below the “exit” key on the keypad. Select the **Light Source Menu.**
3. Verify that the parameters in the **Light Source Menu** are as follows:

- Manual Mode NO
- Wavelength 525nm
- Output NO
- ST CorConst 0.5000*
- Offset all 100-250*
- LED 1 100-250*

These parameters should match those given on the instrument test sheet supplied with the Aurora 1000.

Note: These setting may be different for each nephelometer.

4. After the Aurora 1000 has been running for 2-3 minutes, enter into the **Sys Status Menu** from the **Main Menu,** and verify that all parameters PASS.

5. Enter the **Sys Counts Menu.** The readings will vary, but may be similar to the following:

- Src Set Pt 0
- Dark Count <500*
- Shtr Count 1.085M*
- Meas Count 14.55k*
- Meas Ratio 14.21m

6. Verify that the dark count is less than 500 and relatively stable. (The dark count can go above 1000 if the cell temperature is higher than 30^{o}C).
7. Verify that the shutter count is between 0.800M and 1.6M.
8. Verify that the measure count is greater than 6-10K.

Note: It is recommended that these values be recorded in a system log book for future reference and should be quoted when contacting Ecotech.

Light Source Adjustments

If the Shutter counts or the Measure counts are too low or too high, they can be adjusted in the **Light Source Menu** mentioned above.

1. To increase the shutter count or Measure count, increase LED1 up to a higher value, but no higher than a maximum of 250.
2. Return to the **Sys Counts Menu** and check that the Shutter and Measure counts are at an acceptable level after 1 minute.
    a. The shutter count is only updated every 30 seconds.
    b. The shutter count and measure count will increase or decrease proportionally when adjusting the LED1 setting.
    c. For each wavelength, the optimum settings are for: Measure count > 6 - 10K, Shutter count ~1.2M (0.8M minimum and 1.6M maximum.
    d. LED 1 should be between 100 and 250.
    e. If you cannot adjust the shutter count above 0.8M, then please contact Ecotech for further instructions on how it can be adjusted.
3. When LED 1 has been set, it must be stored by selecting the Set LED Pots item in the **Light Source Menu.**
4. If the light source parameters have been adjusted, then a full calibration will be required.

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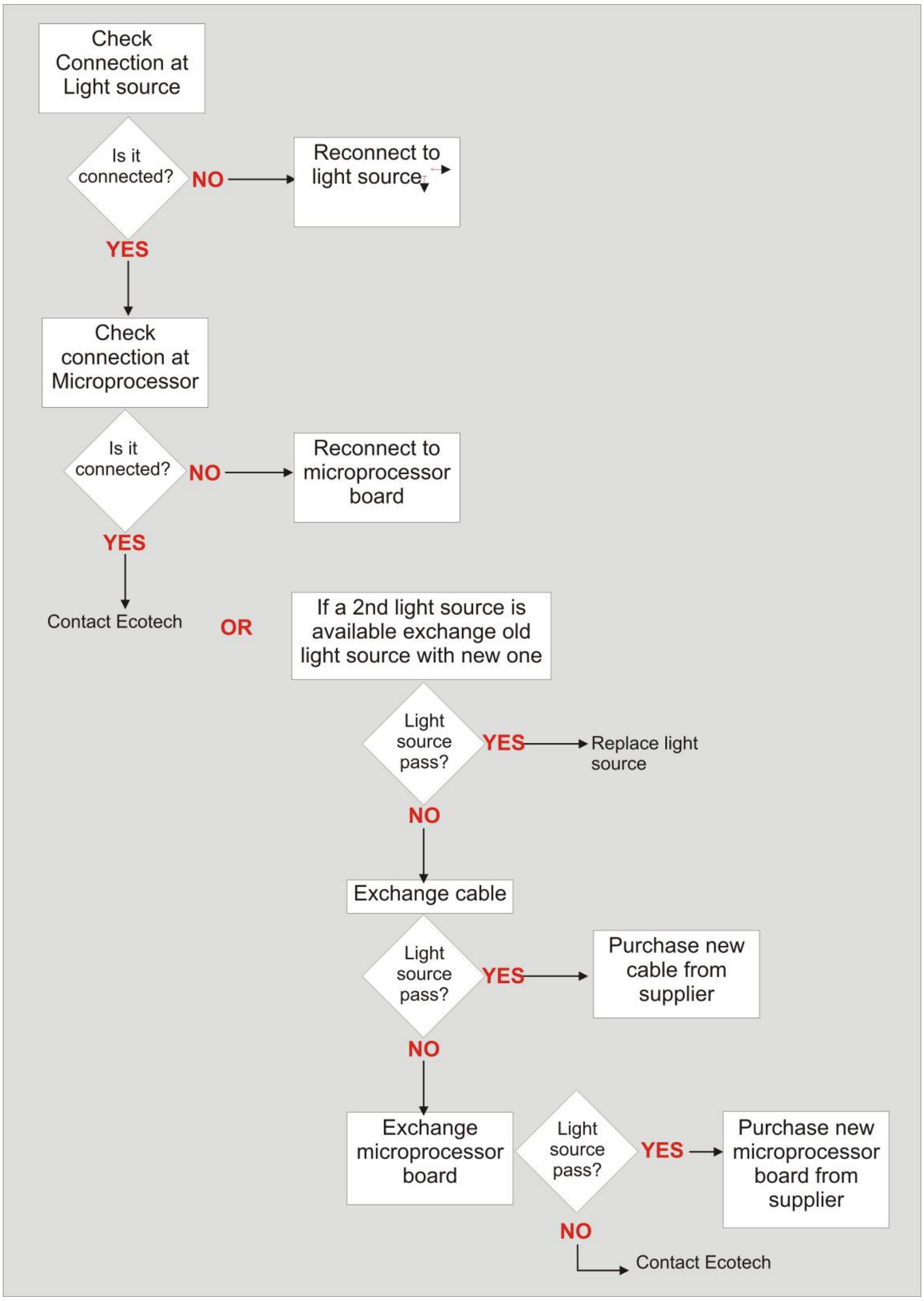
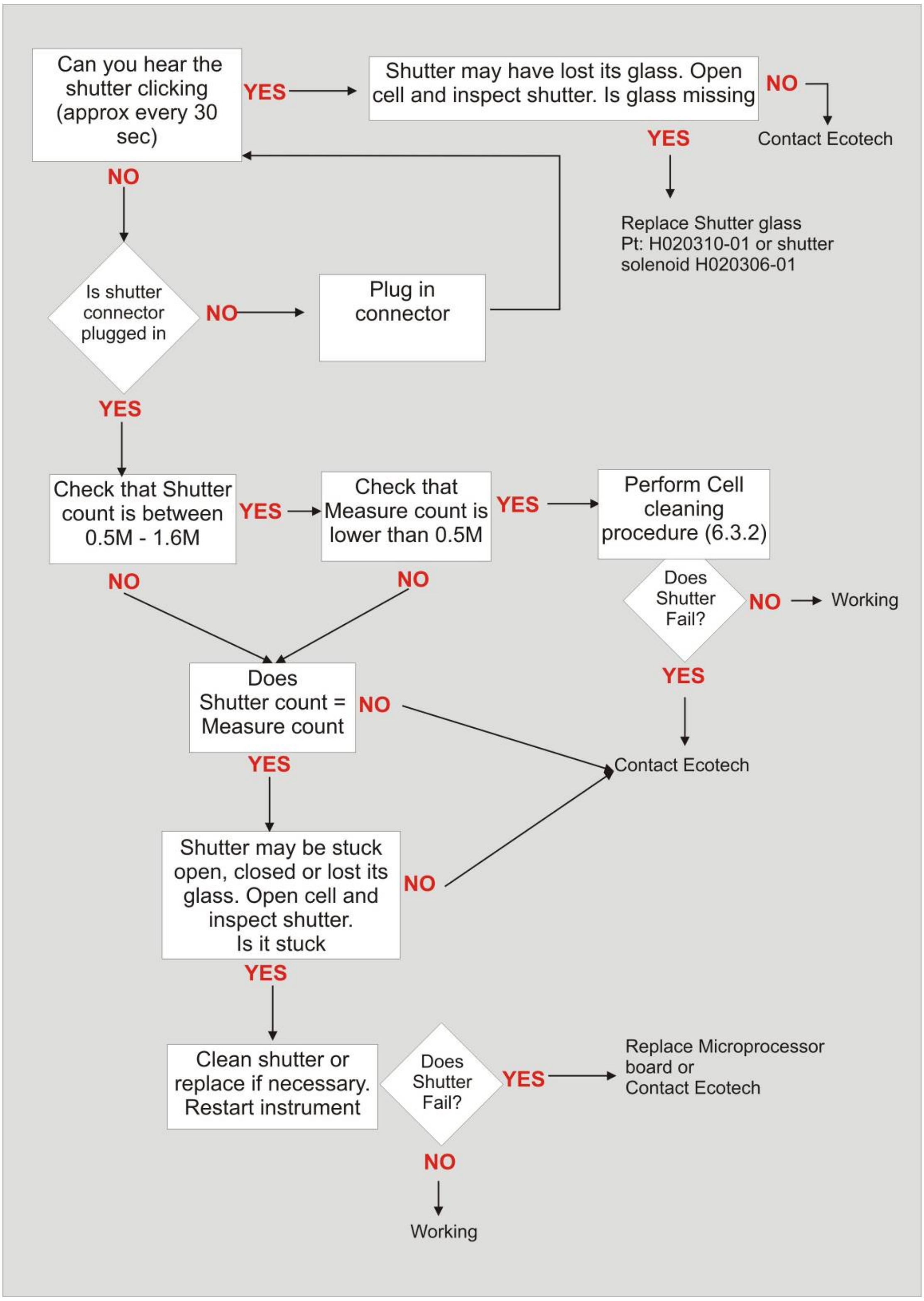
7. Troubleshooting

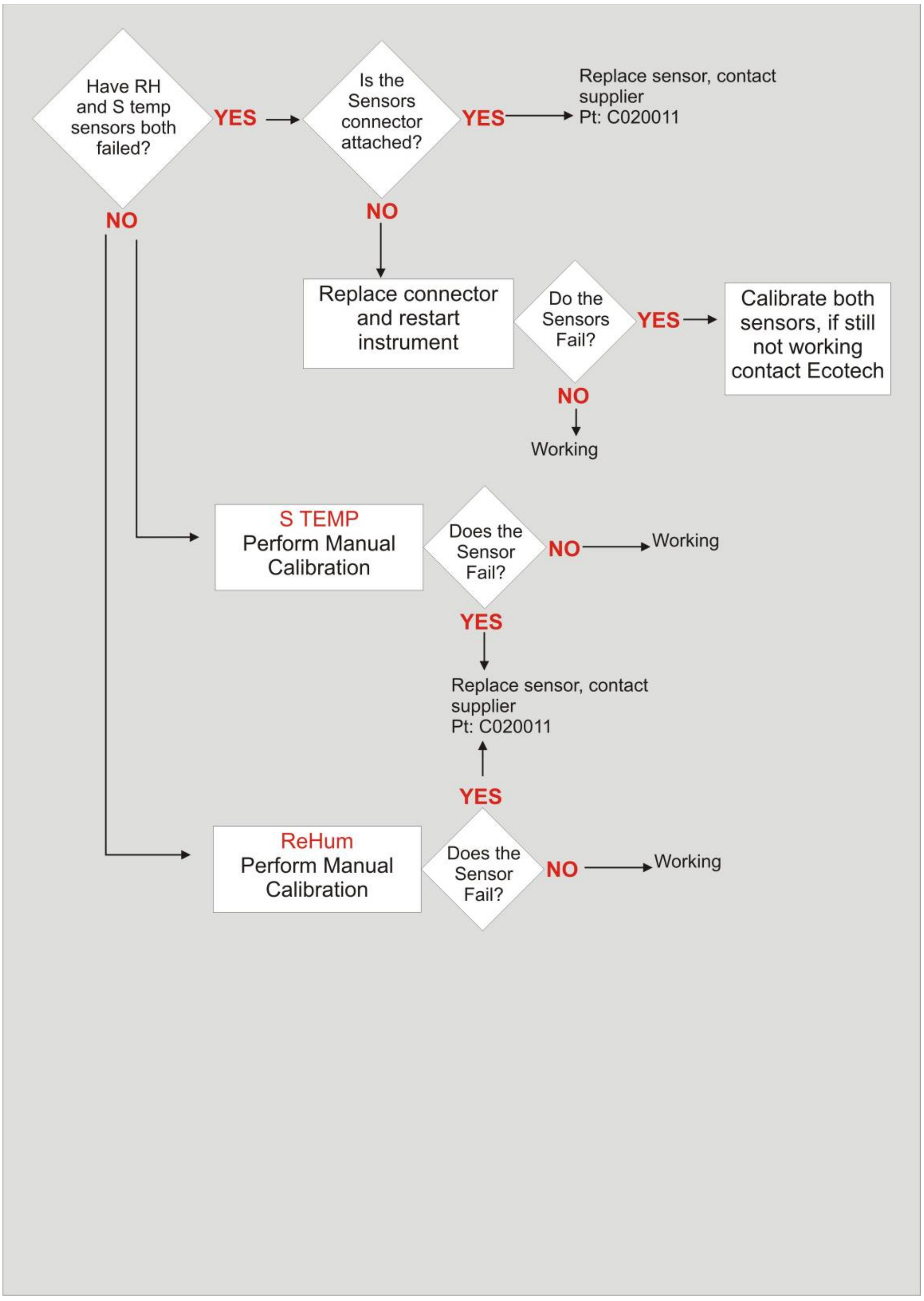
7.1 Light Source Fail



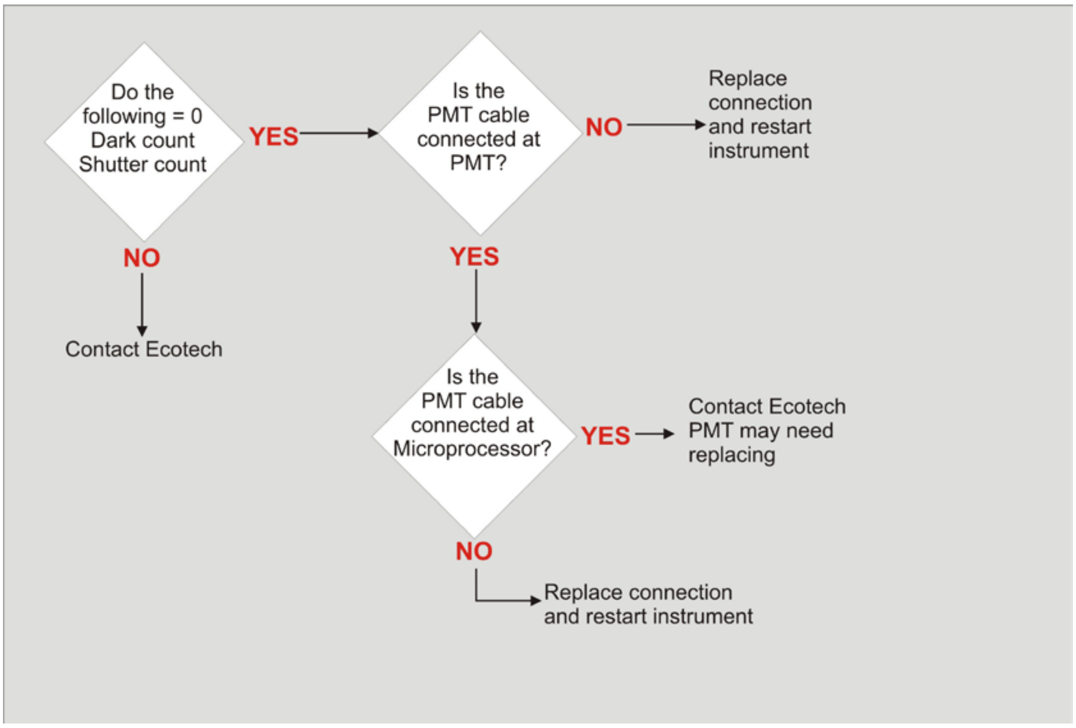
7.2 Reference Shutter Fail



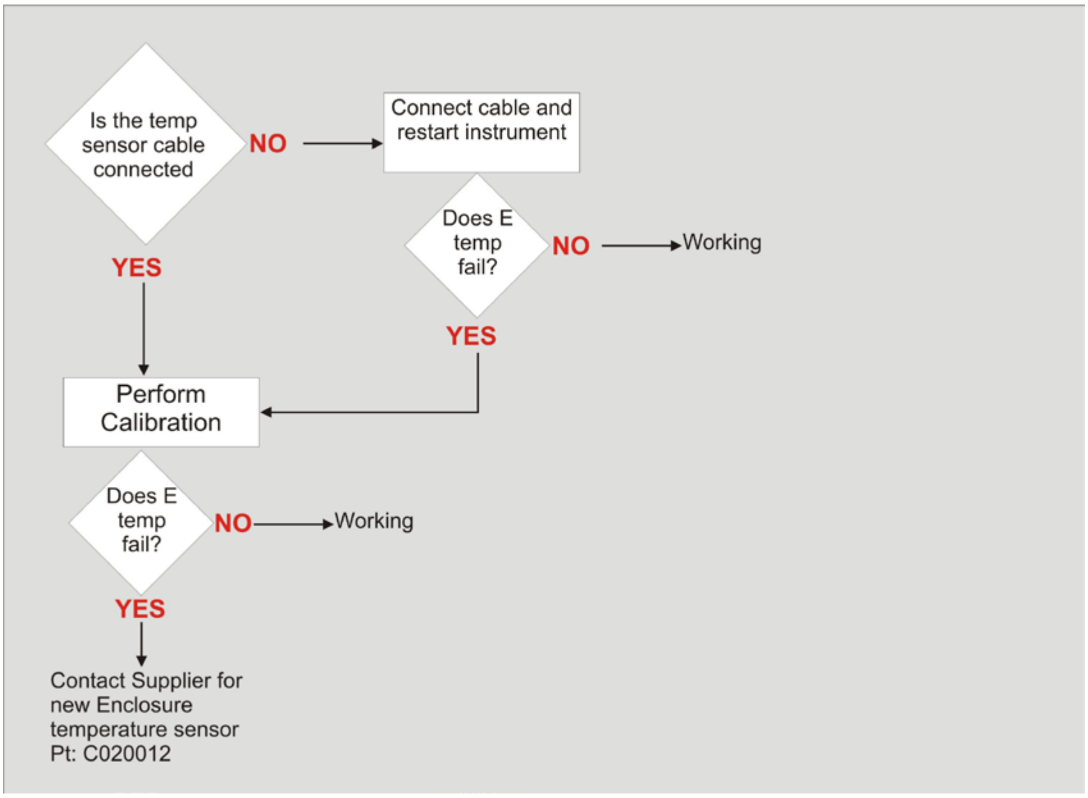
7.3 RH Sensor & Temperature Sensor Fail



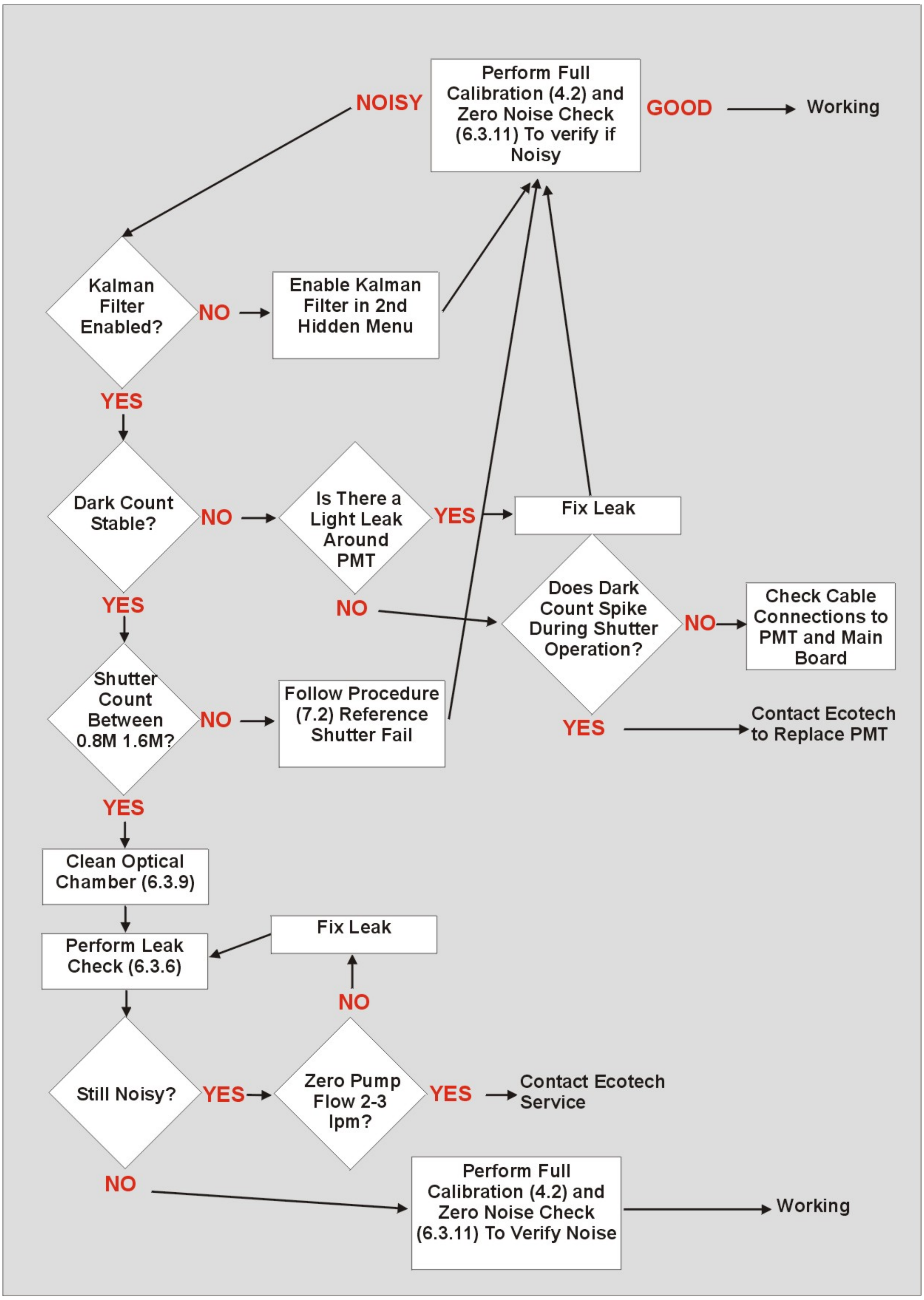
7.4 PMT Fail



7.5 Enclosure Temperature Sensor Fail



7.6 Zero Noise Fail



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8. Optional Extras

8.1 Flow Control – 3 Litre

The $PM_{2.5}$ sampling Aurora Nephelometer is identical to a standard Aurora nephelometer except for the addition of the $PM_{2.5}$ inlet and sample pump. The following document will outline the differences between the two.

8.1.1 Pneumatic Changes

The $PM_{2.5}$ sampling Aurora Nephelometer has some pneumatic alteration to allow $PM_{2.5}$ sampling. The pneumatic changes are based around the pump and are all post measurement cell. Previously after the measurement cell the sample ran through a tube to a fan, which was then expelled from the nephelometer, Figure 51.

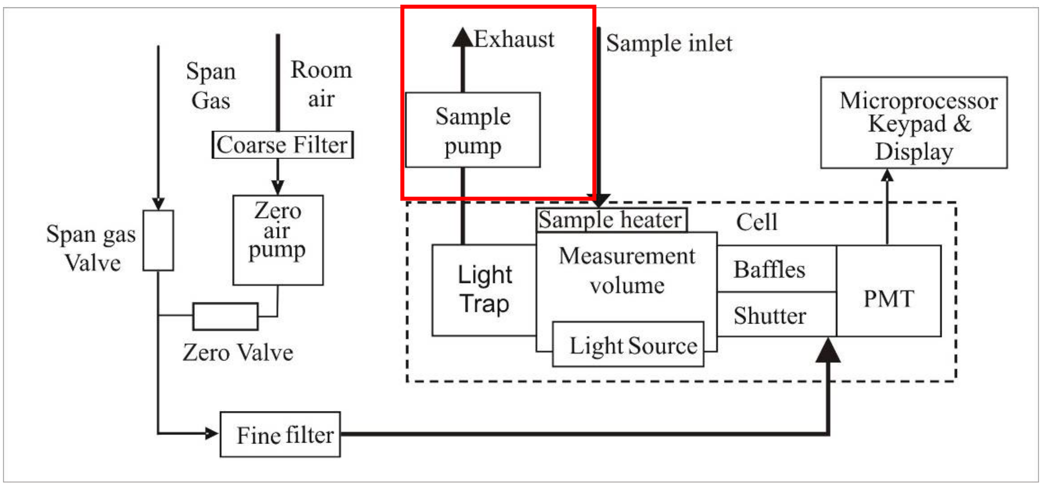

Figure 51 – Aurora 1000 block diagram (red box shows changed pneumatics)

Now the $PM_{2.5}$ sampling nephelometer uses a flow sensor and pump to control the flow, with the inclusion of a buffer tank that creates consistency in the flow. A DFU is also included to protect the flow sensor from damage from particulates.

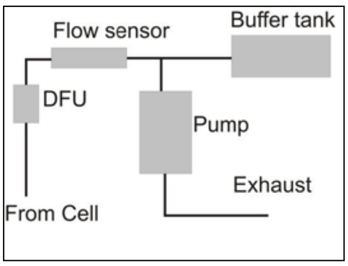

Figure 52 – Pneumatic changes

8.1.2 Removal of Pump Bracket

To access many of the nephelometer's internal components the pump bracket must be removed.

1. Open the front panel so that the internal components can be seen.
2. Remove the three screws highlighted in Figure 53 making sure that the pump module in Figure 50 is being held.

Figure 53 – Pump bracket screws

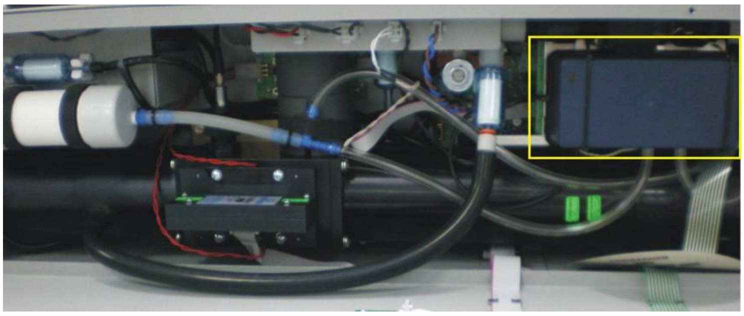

Figure 54 – Pump bracket

3. Pull the pump module out from the case, slowly and carefully ensuring no wires, circuitry or tubing is damaged.

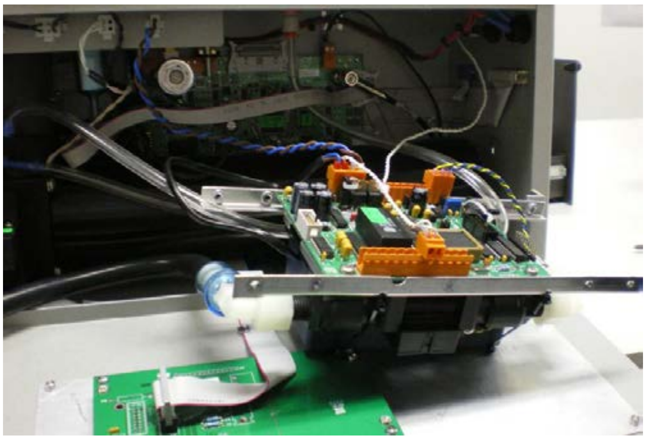

Figure 55 – Pump bracket removed from nephelometer

4. Once the pump has been removed from the chassis, all components behind it can be accessed and maintenance performed where necessary as described in the standard nephelometer manual.

8.1.3 Pump Maintenance

The PM2.5 sampling nephelometer's pump is available as a spare part, and takes only about 10 minutes to replace. This may be required after a period of several years, due to deterioration of the seals.

1. Remove the tube from below the pump, noting which port the pipe is connected to.
2. Turn the sampler on to check whether there is vacuum and pressure on the appropriate ports in Figure 56.

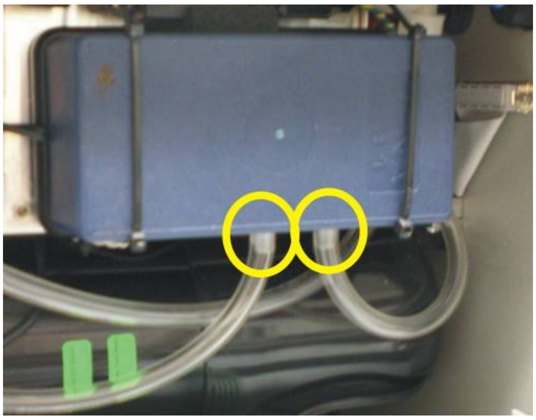

Figure 56 – Pump ports

3. If there appears to be a problem, disconnect the pump terminals from the circuit board, remove the pump from its cable ties and remove the pump from the nephelometer.
4. The pump should be exchanged with a replacement pump- P-ECO-MICRO10006-S.
5. Install new pump and reassemble, the polarity of the pump wires is not important.

8.1.4 $PM_{2.5}$ Inlet Head

The $PM_{2.5}$ inlet sits on top of the sample inlet or sample tubing.

Figure 57 – $PM_{2.5}$ inlet collapsed and expanded

The size-selective inlet is of the impaction type. Ambient air enters the inlet assembly via a rain cap and Stainless Steel insect mesh screen that prevents contamination of the sample by precipitation and large debris. The air is funnelled through an acceleration nozzle where it is directed towards a flat impaction plate that sharply diverts the air stream.

Particles larger than the size cut-point tend to be heavier and hit the impaction plate where they are trapped. Smaller particles remain airborne and continue into the sampler. The size cut-point is affected by air stream velocity/flow-rate, acceleration nozzle diameter, and particle density, composition and shape.

Ambient air is drawn into the size-selective inlet at a constant flow-rate in order to maintain the size cut-point. To achieve this, the $PM_{2.5}$ sampling Aurora nephelometer uses a volumetric flow-rate controller. The flow rate must be set to 3.0 l/min to achieve the correct particle size cut-point.

8.1.5 Cleaning the $PM_{2.5}$ Inlet Assembly

The impactor assembly should be cleaned and re-greased at least every 10 sampling periods and sooner if dirt is visible. Remove the impactor assembly from the filter holder. Remove the rain cap. Remove the connecting tube and impactor plate by pulling them apart. If necessary, the impactor plate and connecting tube may be pushed out by inserting a rod down the inlet jet, taking care not to scratch the jet, then pushing the impactor plate out of the impactor assembly.

Wipe any dirt off the top of the impaction plates using a lint-free cloth. Wipe the inside of the holes to remove all grease and dirt. All components should be wiped initially with a soft clean cloth to remove grease and dirt. They should then be cleaned using warm soapy water and rinsed a couple of times with fresh hot water.

Use compressed air to dry the components. Inspect the O-rings for damage, and replace them if necessary. Always apply a trace of O-ring grease to the O-rings before assembly or they will be damaged.

The impaction plate should be greased lightly in the centre, masking the outer part of the disc so that the grease is only in the centre of the impaction plate – covering an area about 10mm in diameter.

Light petroleum grease such as Vaseline can be used otherwise, silicone grease such as Dow Corning Slipicone release spray can be used. Dry the plate thoroughly with a clean lint-free cloth. If necessary, store in a clean zip-lock bag until ready for use.

The acceleration nozzle orifice should be cleaned after approximately 1000 hours of use, depending on loading. Do not use anything sharp to clean the passage - a soft brush or pipe cleaner and soap solution is sufficient.

8.1.6 Re-assembly

A light smear of silicone O-ring grease should be re-applied to the O-rings as needed to ease assembly and disassembly. When re-assembling sections with O-rings, take care to align the pieces well and to twist and slide them together smoothly to avoid displacing or damaging the O-rings.

The impactor plate locates in the nozzle body, grease side towards the nozzle. The inlet should be held upside-down during assembly. The adaptor tube retains the impactor plate. Apply gentle pressure to the adaptor tube to seat it against the impactor plate.

8.1.7 New Components

Sample Pump & Flow Control Unit

The sample pump is the means by which large volumes of ambient air is drawn in through the sample inlet, through the cell and out the exhaust. This pump runs continuously drawing 3 l/min except during calibration, zeros and start up.   The flow control unit ensures the flow remains at 3 l/min, through the use of a flow sensor, temperature sensor, and pressure sensor.

Figure 58 – Sample pump

Ambient Air Temperature Sensor

The Aurora with flow control requires an ambient air temperature sensor mounted outside so that the correct volumetric flow through the $PM_{2.5}$ inlet can be calculated. The following section details the installation of this. The sensor connects to the Aurora via the modified 'service port', which no longer supports the functionality documented in the standard Aurora manual.

Installation

1. Install the Roof Flange in the appropriate location the roof and use Silicon to seal.
2. Install the Sample inlet Tube (1/2 inch) through the Roof Flange. As every installation will be different, it is up to the customer to supply the appropriate length of tube. Contact Ecotech if tubing is required.

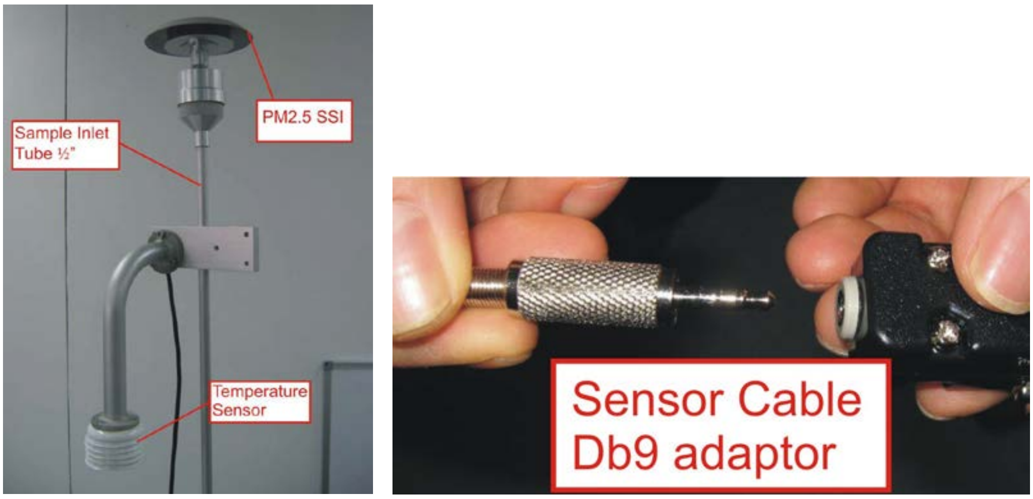

Figure 59 – Installing the ambient air temperature sensor stage 1

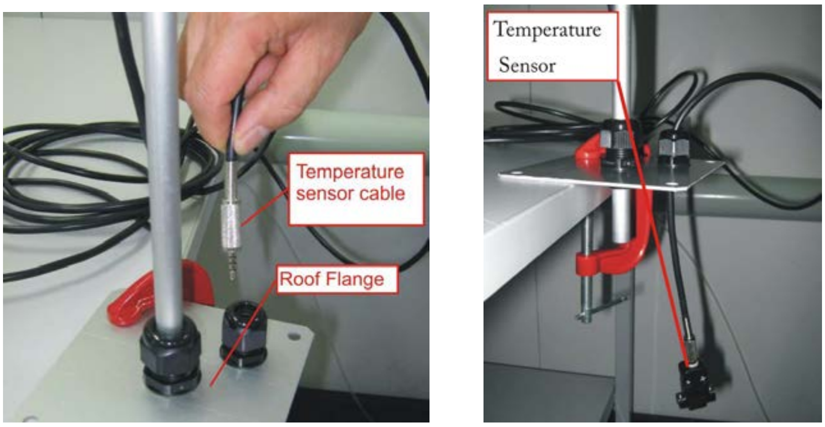

Figure 60 – Installing the ambient air temperature sensor stage 2

1. Clamp the temperature sensor assembly on the sample inlet tube close to the SSI. Tighten the 2 screws accordingly.
2. Pass the temperature sensor cable down through the small cable gland and tighten the gland so it seals around the cable.
3. Now plug the temperature sensor cable into the DB9 adaptor and connect to the Ambient Temperature port on the side of the Aurora.

8.1.8 New Menus

The flow control Aurora Nephelometer has included a new menu with five fields. This menu is used to monitor the nephelometer flow, something not necessary within a standard Aurora nephelometer.

The new menu is called **Flow Option** and is located below the **Leak Test Menu** within the **Main Menu.**

Man FlowCtl

Selecting “yes” will allow the operator to manually turn the sample pump on and off with the Flow Running field below. Selecting “no” the nephelometer will perform normal sampling.

Flow Running

Selecting “yes” will run the sample pump at normal speed. Selecting “no” will turn the sample pump off (only works if the ‘Man Flow Ctl’ option is set to YES).

Flow l/min

Displays the sample flow in units of litres per minute (l/min).

Inlet Temp C

Displays the inlet temperature in units of degrees Celsius. This temperature comes from the sensor that connects to the port labelled ‘service’ on the Aurora. The sensor must be installed close to the size selective inlet head, to ensure that the flow is accurately compensated for the sample temperature as it enters the inlet head.

Pressure Torr

Displays the atmospheric pressure in torr. This is used to correct the flow for variations in pressure. Note that this pressure sensor is mounted on the flow control module, and is entirely separate from the standard Aurora pressure sensor.

8.1.9 Flow Control Module Menu

The flow control module in the Aurora, is very similar to Ecotech's 'MicroVol' in operation, however it only has the core features, so that it performs the sole purpose of controlling the flow through the Aurora accurately.

In the event that the flow control module requires servicing or recalibrating, the display and keypad connectors can be unplugged from the main Aurora microboard PCA, and plugged into the Flow Control Module PCA (the flow control module will need to be removed from the nephelometer to access both these connectors). Calibration of the flow module can then be undertaken as per Ecotech 'MicroVol 1100 manual' instructions.

Note: You will need to power up the Aurora and wait one minute before the flow control module will begin operating, as the pump is switched off during start-up.

The following is a brief description of the **Diagnostics Menus** available in the flow control module. For calibration instruction, refer to the microvolt manual.

Status Screen

The Status Screen displays current MicroVol status information. The data cannot be changed from this screen. Sample volume and Corrected sample volume data is updated every minute, all other data updates instantly. Corrected sample volume is used to calculate particulate concentration and has been corrected to standard Reference conditions.

Note: All YES/NO conditions must be met before sampling takes place in automatic sampling mode.

Flow l/min 3.000	Displays current volumetric flow-rate
Tot. Vol. l 708.02	Displays sample volume
Temp. C 22.90	Displays current ambient temperature
Press. mmHg 763.4	Displays current barometric pressure
Cor.Volume l 650.33	Displays sample volume corrected to STP
RunTime min 890.00	Displays sampling duration (pump running)
Pwr Supply V 11.921	Displays current power supply voltage
M/S Ratio 0.5543	Displays pump load (0.000-1.000)
Day of Week WED	Displays current day of the week

Figure 61 – Status screen

Set-up Menu

The **Set-up Menu** contains a number of sub-menu items and some direct entry parameters, where the user can program various parameters.

Clock →	To Clock Menu
Flow l/min 3.0	Set sampler flow-rate, litres/minute
Ref.Temp. C 0	Set STP standard temperature, °C
Ref. BP mmHg 760	Set STP standard pressure, mmHg

Figure 62 – Setup menu

Note: Flow-rate should be set at 3.0 l/min when using size selective inlets. The size selective inlet particle cut-point will be most accurate when the flow-rate is set 3.0 l/min. Do not set the flow rate below 1.0 or above 3.5 l/min.

Note: Ref. Temp. and Ref BP: Ensure these are set to Standard Temperature and Pressure Conditions (varies between different countries).

Clock Menu

The **Clock Menu** sets the MicroVol clock. Note that times should be entered in 24-hour format.

Date 20/09/2000	Set current date
Time 17:34:00	Set current time

Figure 63 – Clock menu

Note: After changing the **Clock Menu,** time and date parameters, disconnect the power from the base of the MicroVol and then reconnect it. This will initialise the MicroVol using the new clock settings.

Hidden Menu

The **Hidden Menu** is used to set parameters at the factory. It is not usually necessary to access the Hidden Menu.

To access the Hidden Menu, hold down the secret key (the first letter C in the E<u>C</u>OTECH logo), then press the Select key at the same time.

Voltages	→	Diagnostics only
ID	0	Optimised at the factory – do not adjust!
Motor Freq.	40.	0=mm/dd/yyyy (USA)
Date Format	1	1=dd/mm/yyyy (common)
		2=yyyy/mm/dd (Japan)
		dd = day, mm = month, yyyy = year
Flow coeff0	-1.25	Flow calibration coefficient 0
Flow coeff1	1.25	Flow calibration coefficient 1
Temp coeff0	0.381	Temperature calibration coefficient 0
Temp coeff1	0.0192	Temperature calibration coefficient 1
Pres. coeff0	73.	Baro. pressure calibration coefficient 0
Pres. coeff1	168.7	Baro. pressure calibration coefficient 1
Default Prms	→	Resets all **Hidden** menu parameters

Figure 64 – Hidden menu

Flow Control Module Calibration

Check the calibration at least every six months or when the flow-rate, barometric pressure or temperature data is suspect.

Perform the calibration indoors, out of direct sunlight, especially when calibrating the temperature sensor.

Refer to the calibration sheet for factory-calibrated values – these are different to the default values.

To change any of the calibration coefficients, it will be necessary to access the Hidden Menu. Refer to the Hidden Menu section for further information regarding the calibration coefficients.

Temperature Sensor Calibration

1. Record the temperature displayed by the flow controller.
2. Record the actual temperature with a certified precision thermometer.
3. If these measurements are not significantly different nephelometer is working fine.
4. If these measurements are significantly different, continue with the calibration as follows:
5. Calculate $x = \frac{\text{Actual temperature}}{\text{MicroVol temperature}}$
6. Then:

Assign…	**…the value of…**
Temp coeff 1	(Temp coeff 1) ÷ *x*
Temp coeff 0	Do not change

7. Repeat steps 1-4 (if necessary) until the flow controller temperature is close to the actual temperature.

Barometric Pressure Sensor Calibration

1. Record the barometric pressure displayed by the flow controller.
2. Record the actual barometric pressure with a certified pressure gauge or barometer. If these measurements are not significantly different the nephelometer is working fine and needs no adjustment.
3. If these measurements are significantly different, continue with the calibration as follows:

   Calculate the difference between the two values and adjust the barometric pressure coefficient 0 (Pres. coeff0) by this value. If the flow controller is reading high, decrease the value of the coefficient 0, and vice versa. Do not adjust coefficient 1 (Pres. coeff1).
4. Re-check the Flow controller barometric pressure reading.

Flow Rate Calibration

The flow-controller is factory calibrated. Care should be taken to keep moisture out of the inlet tube and the sampler should always be operated with a filter installed. If this is done, the flow controller should maintain its calibration accuracy for extended periods (several years).

The flow-rate may be periodically checked using a bubble flow-meter. Do not use a piston type flow-meter as the piston inertia affects the flow-rate and flow-control system. An optional Flow-rate Checking kit is available for this purpose.

Take care when using the bubble flow-meter so that no liquid gets into the flow controller. Place the flow controller and flow-meter on the same level (eg. on a bench), and connect the flow-meter to the top of the inlet pipe using flexible tubing and push-in fittings.

If the flow-meter and flow controller report different flow-rate readings, first check that there are no leaks in the connecting tubes.

Procedure for Re-calibrating the Flow Controller

1. Set the flow controller flow rate to a particular value and record this value.
2. Measure the actual flow-rate using a bubble flow-meter.
3. Repeat steps 1 and 2 with a different flow-rate. Flow-rates of 2.0 litres/min and 3.0 litres/min are recommended. Record the results in a table (see below). If the flow controller and actual values are significantly different, continue with the calibration. The names in the table are those that will be used in the calculations that follow.

Flow controller flow-rate, l/min	**Actual flow-rate, l/min (measured with bubble-meter)**
SETFLOW1 = (eg. 2.0)	MEASUREFLOW1 =
SETFLOW2 = (eg. 3.0)	MEASUREFLOW2 =

4. Calculate (to four decimal places):

$$A = \frac{\text{MEASUREFLOW1} - \text{MEASUREFLOW2}}{\text{SETFLOW1} - \text{SETFLOW2}}$$

and

$$B = \text{MEASUREFLOW1} - A \times \text{SETFLOW1}$$

5. Then:

Assign…	**…the value of…**
Flow coeff 0_{new}	$(\text{Flow coeff } 0)_{existing} \times A + B$
Flow coeff 1_{new}	$(\text{Flow coeff } 1)_{existing} \times A$

Enter the new values for flow coefficients 0 & 1 at the Hidden menu (refer to Hidden Menu section).

Appendix A. Aurora Command Set

Command: ID

Polls the Aurora 1000 for the instrument type, the current software/firmware version and the unique factory allocated identification number of the nephelometer.

Syntax:	ID{<module address>}<CR>
Response:	Ecotech Aurora 1000 Nephelometer v{<firmware version number>}, ID #{<instrument ID number>}<CR><LF>
Example:	ID0<CR> may respond with: Ecotech Aurora 1000 Nephelometer v2.00, ID #123456 <CR><LF>
Related Commands:	Pressing CONTROL also gives the same response.

Command: **PS

Programs the unique factory allocated identification number of the nephelometer into memory. This number can be found in the bottom line of the Main menu.

Syntax:	**{<module address>}PS{space}{<instrument ID number>}<CR>
Response:	OK<CR><LF>
Arguments:	<instrument ID> is a six digit number allocated by Ecotech to each individual instrument.
Example:	**0PS_123456<CR> responds with: OK<CR><LF> and sets the instrument ID number to 123456.

Command: **B

Re-Boot test. When initiated the Watchdog timer will be activated and cause the Aurora 1000 microprocessor to re-boot. The same as pressing the reset button on the microprocessor board.

Syntax:	**{<module address>}B<CR>
Response:	null
Example:	**0B<CR> will re-boot the Aurora.

Command: **M

Enables/Disables the remote menu feature of the Aurora 1000. When enabled, the user can perform all menu operations remotely using a RS232 terminal connected to the Service port.

Syntax:	**{<module address>}M{<remote menu status>}<CR>
Response:	OK<CR><LF>
Arguments:	<remote menu status>= 1 turns the remote menu ON. <remote menu status>= 0 turns the remote menu OFF
Example:	**0M1<CR> responds with: OK<CR><LF> and turns the remote menu on.

Command: **S

Sets the real-time clock on the Aurora 1000 microprocessor board. A single command can set the time and date.

Syntax:	**{<module address>}S{<hhmmssddMMyy>}<CR>
Response:	OK<CR><LF>
Arguments:	<hhmmssddMMyy> is the current time and date. (hh) hour, (mm) minutes, (ss) seconds, (dd) day, (MM) Month, (yy) year.
Example:	**0S142536061003<CR> responds with: OK<CR><LF> and sets the clock to: 14:25:36 on 6/10/2003.

Command: **PC

Programs the calibration parameters for the analog inputs and analog outputs. This is used mostly during factory calibration.

Syntax:	**{<module address>}PC{<calibration parameter>}{<calibration value>}<CR>	
Response:	OK<CR><LF>	
Arguments:	`<calibration parameter>` = one of the following:	
	0	Calibration Pressure X point - pressure in kpa at calibration point.
	1	Calibration Pressure Y point - A2D reading at calibration point.
	2	Calibration thermistor factor - A2D reading of thermistor at 25 degrees.
	3	Calibration Vaisala temperature offset - Vaisala temperature offset at minimum reading.
	4	Calibration RH gradient - Vaisala RH gradient correction factor.
	5	Calibration RH offset - Vaisala RH offset adjustment.

Syntax:	**{<module address>}PC{<calibration parameter>}{<calibration value>}<CR>	
	6	Analogue Output Current 1 Zero A/D point.
	7	Analogue Output Current 1 Full A/D point.
	8	Analogue Output Current 2 Zero A/D point.
	9	Analogue Output Current 2 Full A/D point.
	<calibration value> = an appropriate value to set each calibration point.	
Example:	**0PC01013.25<CR> responds with: OK<CR><LF> and programs the calibration pressure X point to 1013.25.	

Command: **J

Forces or Jumps the Aurora program into one of the 8 major states. This is used mostly during factory testing.

Syntax:	**{<module address>}J{<major state number>}<CR>	
Response:	TOK<CR><LF>T	
Arguments:	<major state number> = one of the following:	
	0	Normal Monitoring.
	1	Span calibration (adjusts calibration curve).
	2	Zero calibration (adjusts calibration curve).
	3	Span check.
	4	Zero check.
	5	Zero offset adjust (adjusts calibration curve).

Syntax:	**{<module address>}J{<major state number>}<CR>	
	6	System calibration / start-up.
	7	Environmental calibration.
Example:	**0J6<CR> responds with: OK<CR><LF> and forces the Aurora 1000 into system calibration (or start up).	

Command: DO

Overrides the digital input and output control. Most commonly this command is used to force the Aurora 1000 into either span or zero measure mode.

Syntax:	DO{<module
Response:	TOK<CR><LF>T
Arguments:	<digital parameter number> = one of the following:
Example:	00 External DOSPAN control override. 02 Filtered air valve on/off (not used).
	03 Output valve on/off (not used).
	04 Digital out Aux control override.
	05 Sample pump control override.
	10 LCD backlight control override.
	<digital parameter state> = 1turns digital parameter ON. <digital parameter state> = 0 turns digital parameter OFF.
Example:	DO0001<CR> responds with: OK<CR><LF> and sets the AURORA 1000 into span measure.

Command: VI

Reads up to 100 different parameters from the Aurora 1000 microprocessor. Ideal for data logging devices which can poll the nephelometer for its data.

Syntax:	TVI{<module address>}{<voltage input parameter number>}<CR>T	
Response:	{<sign>}{<parameter value>}<CR><LF>	
Arguments:	T<sign> = <space>T if positive, T<-> if negative. (if the output is an ASCII character, then there is no T<sign>.	
	T<parameter value>= a value which can be either an ASCII character string, or a decimal number to six decimal places.	
	< voltage input parameter number > = one of the following:	
See Note 1.	00	Scat coefficient . Mm -1
	01	Sample temperature. K
	02	Relative humidity. %
	03	Enclosure temperature. K
	04	Atmospheric pressure. mBar
	05	Dark count (moving average).
	06	Shutter count (moving average).
	07	Scat coefficient 5 minute average.
	08	Measurement ratio (moving average).
	09	Measurement ratio last reading.
	10	Measurement photon count last reading .

Syntax:	TVI{<module address>}{<voltage input parameter number>}<CR>T	
	11	Dark count last reading.
	12	Shutter count last reading.
	13	Atmospheric pressure 5 minute average. mBar
	14	Air temperature 5 minute average. K
	15	Cell temperature 5 minute average. K
	16	Relative humidity 5 minute average. %
	17	Air temperature in current reporting preference.
	18	Cell temperature in current reporting preference.
	19	Atmospheric pressure in current reporting reference.
	20	Air temperature 5 minute average in current reporting preference.
	21	Cell temperature 5 minute average in current reporting preference.
	22	Atmospheric pressure 5 minute average in current reporting preference.
	23	Shutter count sanity checking lower limit.
	24	Shutter count sanity checking upper limit.
	25	Calibration measurement count (moving average) - active only when a calibration is occurring.
	26	Calibration measurement count last reading - active only when a calibration is occurring.
	27	Calibration standard deviation - active only when a calibration is occurring.

Syntax:	TVI{<module address>}{<voltage input parameter number>}<CR>T	
	28T	Calibration stability - active only when a calibration is occurring.
	T29T	<BLANK>
	T30T	Calibration Pressure X point - pressure in mBar at calibration point.
	30	Calibration Pressure Y point - A2D reading at calibration point.
	32	Calibration thermistor factor - A2D reading of thermistor at 25 degrees C.
	33	Calibration Vaisala temperature offset - Vaisala temperature offset at minimum reading. K
	34	Calibration RH gradient - Vaisala RH gradient correction factor.
	35	Calibration RH offset - Vaisala RH offset adjustment.
	36	Calibration Gradient - gradient of calibration line.
	37	Calibration offset - offset of calibration line.
	38	Calibration wall scatter - wall scatter calculated from calibration gradient and offset. %
	39	Kalman Filter Gain
	40	Calibration Span X - extinction coefficient at span gas cal point.
	41	Calibration Span Y - measurement ratio at span gas cal point.
	42	Calibration Span temp - temperature at span gas cal point.
	43	Calibration Span pressure - pressure at span gas cal point.
	44	Calibration Zero X - extinction coefficient at zero air cal point.

Syntax:	TVI{<module address>}{<voltage input parameter number>}<CR>T	
	45	Calibration Zero Y - measurement ratio at zero air cal point.
	46	Calibration Zero temp - temperature at zero air cal point. K
	47	Calibration Zero pressure - pressure at zero air cal point. mBar
	48	Calibration Zero Adjust X - extinction coefficient at zero adjust cal point.
	49	Calibration Zero Adjust Y - measurement ratio at zero adjust cal point.
	50	Calibration Zero Adjust temp - temperature at zero adjust cal point. K
	51	Calibration Zero Adjust pressure - pressure at zero adjust cal point. mBar
	52	Analogue Output Current 1 Zero A/D point.
	53	Analogue Output Current 1 Full A/D point.
	54	Analogue Output Current 2 Zero A/D point.
	55	Analogue Output Current 2 Full A/D point.
	56	Calibration Span Check. Mm -1
	57	Calibration Span Stability. %
	58	Calibration Zero Check. Mm -1
	59	Calibration Zero Stability. %
	60	LED Wavelength setting (string).
	61	Desired RH setting (string).
	62	Normalise temperature setting (string).

Syntax:	TVI{<module address>}{<voltage input parameter number>}<CR>T	
	63	Span gas setting (string).
	64	Date format setting (string).
	65	Temperature unit setting (string).
	66	Atmospheric pressure unit setting (string).
	67	Zero check frequency setting (string).
	68	Major state (string).
	69	Minor state (string).
	70	LED Set position (string).
	71	RS232 DO span/zero measure mode status. 016= span, 032= zero.
	80	Clock date (in current report preference format) (string).
	81	Clock time in hh:mm:ss format (string).
See Note 2.	90	Digital output status – PortD (string).
See Note 3.	99	Real time parameters obtained as one comma delimited string.
Example:	VI000<CR> responds with current bsp (Mm -1) 26.3450 <CR><LF>. VI017<CR> responds with current air temp (°C) 22.529816 <CR><LF>. VI004<CR> responds with current pressure (mBar) 26.34 <CR><LF>. VI063<CR> responds with current span gas setting FM200 <CR><LF>.	

Note 1: Major State

The VI000 command for reading the scattering coefficient is unique. It only has an output to 4 decimal places. The 4th digit after the decimal place denotes the major state which the nephelometer is in. The major state is represented by a number (0-7).

Syntax:	VI{<module address>}00<CR>	
Response:	{<sign>}{<parameter value>}{<major state>}<CR><LF>	
Arguments:	<sign> = <space> if positive, <-> if negative.	
	<parameter value> = current bsp (Mm-1) to 3 decimal places.	
	<major state> = one of the following:	
	0	Normal Monitoring.
	1	Span calibration (adjusts calibration curve).
	2	Zero calibration (adjusts calibration curve).
	3	Span check.
	4	Zero check.
	5	Zero offset adjust (adjusts calibration curve).
	6	System calibration /start-up.
	7	Environmental calibration.
Example:	VI000<CR> responds with current bsp (Mm-1) 26.3450<CR><LF>. Indicating that it is in Normal Monitoring state.	
	VI000<CR> responds with current bsp (Mm-1) 26.3453<CR><LF>. Indicating that it is in Span Check state.	

Note 2: Digital Output Status

The VI090 command reads the Digital Output Status of the Aurora 1000 microprocessor board. The DIO status is the status of the digital outputs in hexadecimal. This enables you to determine exactly what the Aurora 1000 is doing. ie if in span or zero measure.

Syntax:	VI{<module address>}90<CR>	
Response:	{<DIO state>}<CR><LF>	
Arguments:	<DIO state> = a hexadecimal number represented by the following:	
	00	Cell heater OFF
	01	Inlet heater OFF
	02	Sample pump ON
	03	Zero pump ON
	04	Span gas valve open
	05	not used
	06	not used
	07	Digital aux out ON
Example:	VI090<CR> responds with 07<CR><LF>. Indicating: cell heater off, inlet heater off, sample pump on.	
	VI090<CR> responds with 0B<CR><LF>. Indicating: cell heater off, inlet heater off, sample pump off, zero pump on. (zero measure).	
	VI090<CR> responds with 13<CR><LF>. Indicating: cell heater off, inlet heater off, sample pump off, zero pump off, span valve open. (span measure).	

Note 3: Single Line Output

The VI099 command provides a unique output string. In one line it provides the time and date, scattering coefficient as well as the other meteorological parameters and current state information. The data is comma delimited.

Syntax:	VI{<module address>}99<CR>
Response:	{<date>},{<time>},{<scattering>},{<air temp>},{<cell temp>},{<RH>},{<pressure>},{<major state>},{<DIO state>}<CR><LF>
Arguments:	<date> = Current date. Format as set in Report Preferences.
	<time> = Current time. hh:mm:ss.
	<scattering> = Current σsp in Mm-1.
	<air temp> = Current Air temp. Units as set in Report Preferences.
	<cell temp> = Cell temp. Units as set in Report Preferences.
	<RH> = Current Relative Humidity. Units in %.
	<pressure> = Current Barometric Pressure. Units as set in Report Preferences.
	<major state> = Major State as listed in Note 1. 2 digit number.
	<DIO state> = DIO State as listed in Note 2.
	<sign> = <space> if positive, <-> if negative.
Example:	VI099<CR> responds with: 21/11/2003 09:45:27, 10.483, 22.108, 21.710, 41.370, 1000.436,00,07<CR><LF>. Indicating that it is in Normal Monitoring state.
	VI099<CR> responds with: 21/11/2003 09:56:10, -0.324, 22.894, 20.952, 40.671, 1000.642,04,0B<CR><LF>. Indicating that it is in Zero Check state.

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