Technical Specification of Scientific Equipment

Technical Specification Number:	**ARA/MRF/033005**
Title:	**Core Chemistry Rack**
Issue Number:	**DRAFT**
Date:	**01/07/02**
Changes:	**001.1 21/10/2002**
	02 21/03/2003 **(after weight reduction)**
	03 DRAFT JULY 2006
	04 SEPTEMBER 2006
	05 OCTOBER 2006
	06 FINAL 23/10/2006
	07 AFTER INSPECTION NOV 2006
	Includes new orientation, new drier and new model of CO pump which is now 230V rather then 3 phase power
Rack Identification Number:	**ARA-06-0602**

Summary

This document provides the technical specification of the installation of the Core Chemistry equipment onto a standard equipment rack for use on the BAe 146 Atmospheric Research Aircraft

Compiled by

Dr Ruth Purvis
Atmospheric Chemist
FAAM
Building 125
Cranfield University
Cranfield
MK43 0AL

Atmospheric Research Aircraft

Technical Specification of Scientific Equipment

Equipment Title: Core Chemistry Rack
Rack Identification number: ARA-06-0602

Overview

General Description of installation:
The Core Chemistry Rack will house four of the basic atmospheric chemistry monitors. It is self-contained and includes all gases and pumps required to operate the four instruments as well as a seating position for up to two scientists. The use of this rack usually requires one operator to control and supervise its use. The instruments require connections to the Air Sample and Exhaust pipes.

Installation required by: FIRST FLIGHT

Instrument Requirement Document number: N/A

Specification prepared by: Dr R Purvis

Tel: 01234 754534 rupu@faam.ac.uk

Contents

2. Functions and Operation of the Core Chemistry Rack

The Core Chemistry Rack houses four atmospheric chemistry monitors.
It is self-contained and gases and pumps required for the operation of these instruments are installed within the rack. All controls for the operation of these instruments are accessed from the seating position.

It is expected that the rack will require one scientist to operate and monitor the instruments.

Another seating position is available for an additional scientist with connections to the main computing system accessible from the front panel to allow use of additional laptop PC.

Basic operating instructions are detailed in Control and Display appendix.

3. Main Equipment Fitted

The following equipment is housed in the Core Chemistry rack.

- Ozone Monitor
- CO Monitor
- NO_X Monitor
- SO_2 Monitor OR Ozone Reference Monitor

Three pumps are required to provide the optimum sample flow for these instruments

- Ozone Pump
- NO_x Pump
- CO Pump

Three compressed gas cylinders are required for the CO monitor

- N_2 high purity 2L @ 100 bar
- 0.25 % CO_2 balance Argon 10 L @ 200 bar
- 529 ppbV CO in synthetic air 2L @ 200 bar

4. Technical Requirements for Installation of Rack Mounted Equipment

The following summary details how the technical requirements have been met.

i) Attachment
All attachments of items to the rack or internal shelves are designed to restrain the equipment under the required inertia loading. This includes preventing the equipment from shifting in a manner that could pose a hazard to the aircraft or its occupants or nullify any of the escape facilities. Centre of gravity analysis shows rack weight distribution. Summary of Attachments gives details of methods of fastening and any fastenings used.

ii) Marking
All components are identified by a unique number as shown in the Equipment List. All cables are identified with unique marking as shown in relevant cable schedules.

iii) Injury precautions
Rack layout and fastenings of components are designed to minimise risk of injury. Sharp edges and protrusions have been removed. Electrical connections follow best practice to ensure minimal risk of electric shock to occupants or servicing personnel.

iv) Protrusion
There are no protrusions into the aisle from the equipment on the core chemistry rack.

v) EMC
The core chemistry rack does not appear to have any effect on aircraft systems. Many tests have been conducted.

vi) Drains
No liquids are used and therefore no drains are fitted.

5. **Scientific Equipment Approval – Conformity Statements**

General

The Core Chemistry rack and the equipment housed therein is only required for scientific use. With the exception of the flight intercom, rack mounted instruments are not directly connected to the flight systems.
The Core Chemistry rack is not required for safe operation of the aircraft. Any failure of systems within or connected to the rack are consider to be from the "no hazard to aircraft or occupants" perspective.
The conformity notes refer to all items of equipment housed in the Core Chemistry rack unless a particular element is specified

Statements of Conformity

1. The design of the Core Chemistry rack contains no feature inherently hazardous to the aircraft or its occupants
2. Materials used in its construction are appropriate for the intended function
3. Fabrication methods meet expected service conditions
4. Fasteners used are appropriate for the aircraft environment
5. Components are labelled to allow identification
6. No flammable liquids are used in the Core Chemistry rack
7. No excessive noise is emitted
8. All electrical components are designed to minimise the risk of electric shock
9. No component handled during normal operation is subject to a temperature rise likely to cause injury.
10. No hazard is likely to arise from operation of the equipment as a result of the changes in temperature and pressure within the normal flight envelope.
11. The equipment will not present a hazard as a result of changes in humidity.
12. Failure of installed component equipment due to shock or vibration is not considered to present a hazard to aircraft or its occupants. No explosive substances are embodied in the instrument.
13. Equipment does not require waterproofing as it is mounted above the floor within the pressure shell
14. The installed equipment has no inherent susceptibility to aircraft fluids such that it causes a hazard.
15. Sand and dust ingress is not applicable as equipment is mounted above the floor within the pressure shell
16. No hazards due to high-energy rotors are present. The pump motors are considered to be of a negligible hazard
17. Fungus resistance is not applicable as equipment is mounted above the floor within the pressure shell
18. Salt spray is not applicable as equipment is mounted above the floor within the pressure shell
19. The installed equipment has no unusually high magnetic effects
20. Failure of the installed component equipment due to power input voltage spikes is not considered to present a hazard to the aircraft or its occupants
21. The installed equipment is not unduly sensitive to audio frequency power inputs
22. The installed equipment is not unduly sensitive to induced signal

23. The installed equipment is not unduly sensitive to radio frequency power inputs
24. The equipment installed in the Core Chemistry Rack has been designed not to affect aircraft systems
25. The equipment is internally mounted, and is therefore not susceptible to direct lightening effects.
26. Icing is not applicable as equipment is mounted above the floor within the pressure shell

6. Failure Analysis

1. No flammable, toxic, corrosive or cryogenic fluids are used in the Core Chemistry Rack. Gases are contained in commercially supplied certified cylinders. All gas pipe work distributing pressurised gases is stainless steel tubing and fittings appropriate to the pressure of the gas.
2. No high power lasers are present. Low power lasers in CD-ROM drives do not present any hazard. The UV lamps in the equipment are completely contained.
3. No high energy rotating parts are fitted. The rack is limited to small equipment ventilation fans, small pumps and CD ROM drives.
4. All gas distribution components are suitable for the pressure of the gases. This includes gas cylinders, pipe work, gas pressure regulators, stainless steel pipe work and fittings. PFA pipe work is only used for low-pressure air distribution between the air sample pipe and the instrument and the exhaust and the instruments.
5. No part of the installed equipment is inherently prone to give rise to a hazardous ignition source in the event of failure.
6. No part of the installed equipment is inherently prone to give rise to a hazardous heat source in the event of failure.
7. Electrical connections follow best practice. No electrical component failure has led to an electric shock hazard in previous operational experience.

7. **Equipment List**

Item Number	ID	Name
1	TECO49	TECO 49 Ozone Monitor
2	AL5002	AL5002 CO Monitor
3	TECO42	TECO 42 NOx Monitor
4	TECO43	TECO 43 SO2 Monitor
5	TECO49C	TECO 49C Ozone Monitor
6	COPUMP	CO Pump
7	O3PUMP	Ozone Pump
8	NOXPUMP	NOx Pump
9	BUFFERVOL	Sample air buffer volume
10	PURIFIER	Inert gas purifier
11	NAFION1	Perma pure drier #1
12	N2MOUNT	Small gas cylinder mounting #1
13	LAMPMOUNT	Large gas cylinder mounting
14	STANDARDMOUNT	Small gas cylinder mounting #2
15	N2REG	Gas Regulator #1
16	LAMPREG	Gas Regulator #2
17	STANDARDREG	Gas Regulator #3
18	N2GAS	Gas Cylinder #1
19	LAMPGAS	Gas Cylinder #2
20	STANDARDGAS	Gas Cylinder #3
21	POWERPANEL	Power Distribution Panel
22	CONTROLPANEL	Control Panel
23	DRIER1	Small drierite drier
24	DRIER2	Large drierite drier

8. Rack Layout Schematic

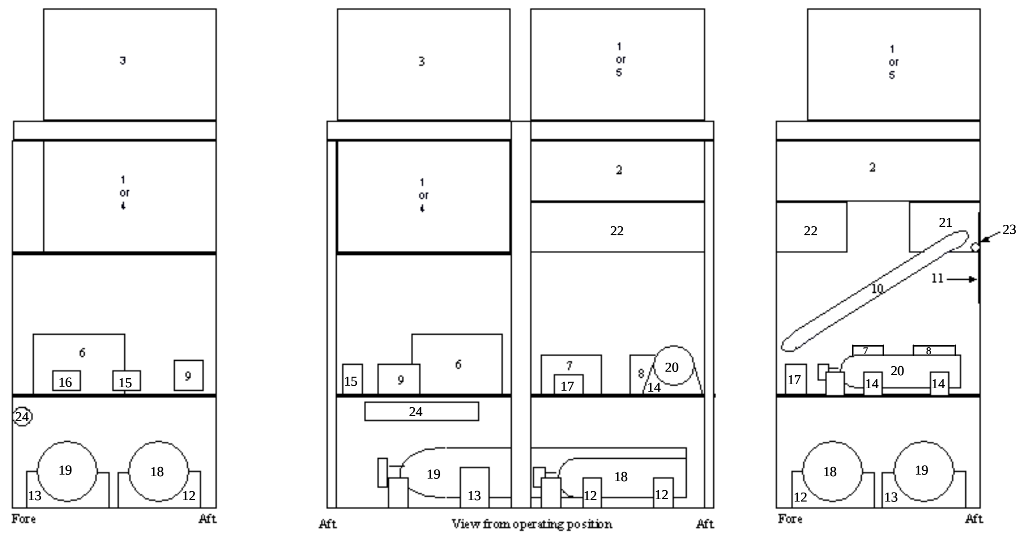

Figure 1 Rack Schematic

9. Card Frames

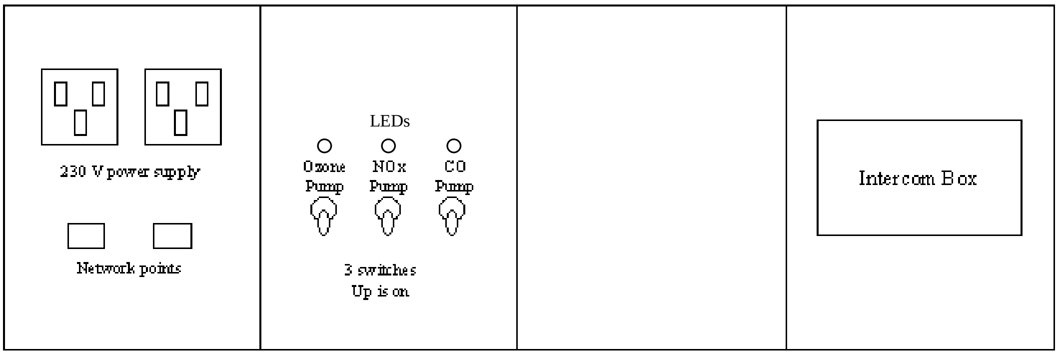

Figure 2 Rear Face Operators Controls

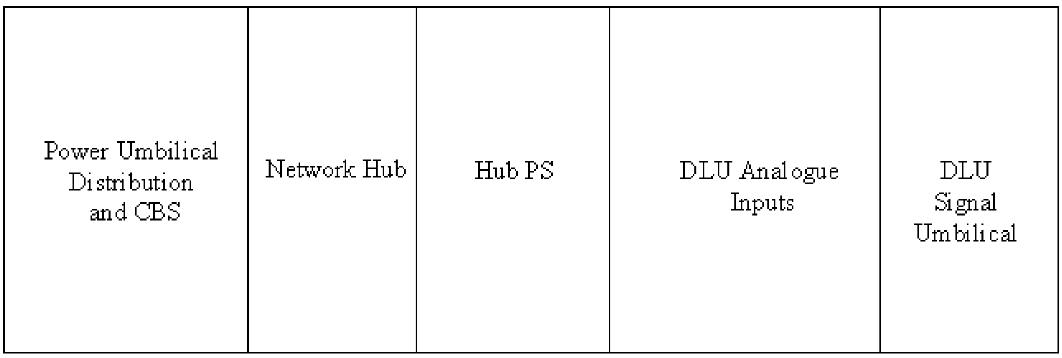

Figure 3 Forward Face Cable Connections

10. Pipe work Schematic and cable schematic

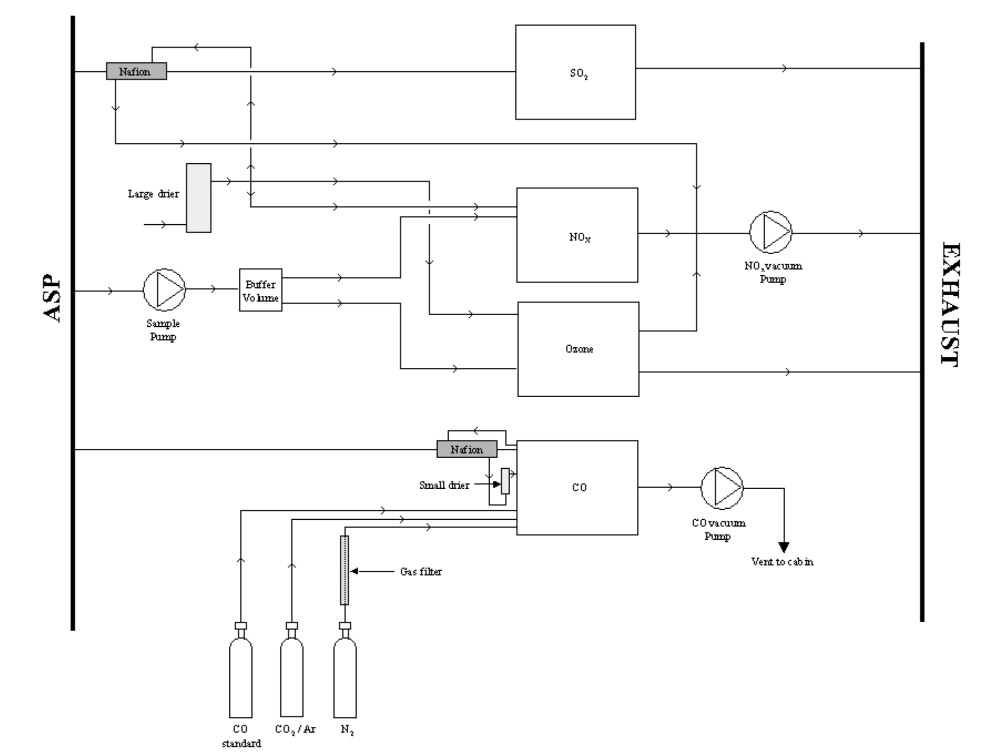

Figure 4 Pipe work schematic for layout 1 (SO_2)

The rack will either contain the SO2 monitor (layout 1) or an ozone monitor (layout 2). The ozone is for reference use only and during flight will not be switched on, therefore has no pipe work.

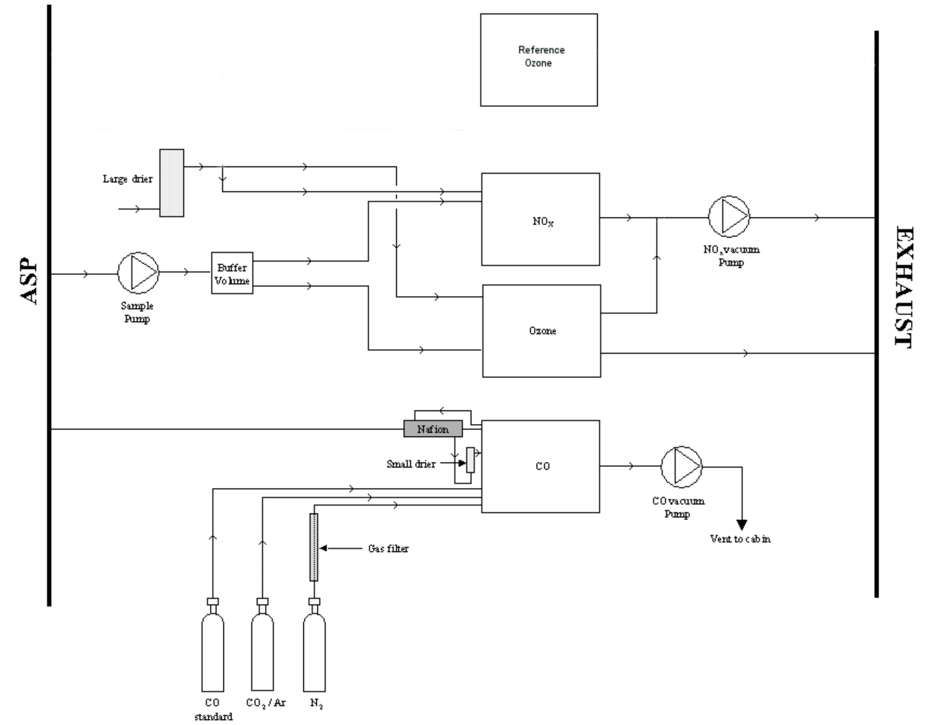

Figure 5 Pipe work schematic for layout 2 (Reference Ozone)

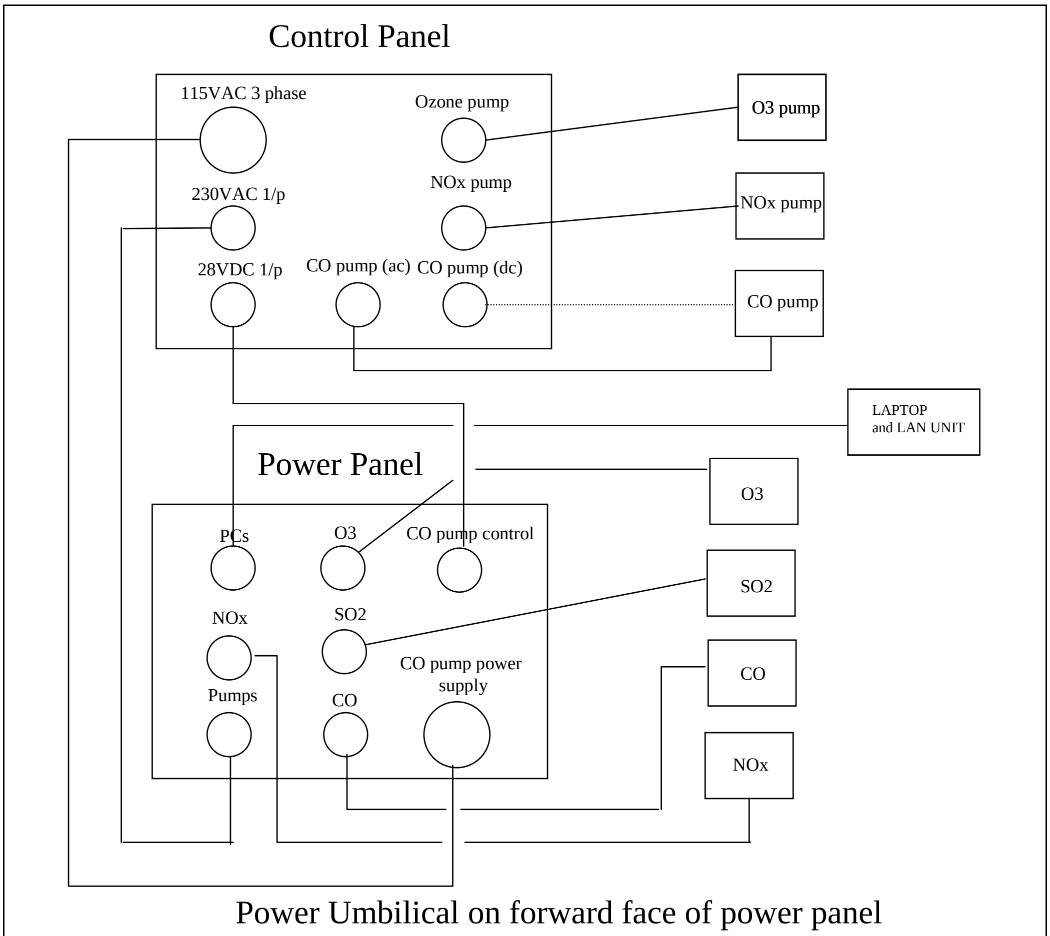

Figure 6 cable schematic

11. Centre of Gravity Analysis

The equipment fitted in the Core Chemistry rack is made up of many items. The following calculations are based on the Centre of Gravity (C of G) of each item being at the geometric mid point.

Item No	Mass (kg)	Height (m)	Moment	Notes
1 or 4	24.00	1.09	26.16	lhs
½ top shelf	4.09	0.94	3.84	Rhs
2	20.00	0.79	15.80	"
21	3.60	0.69	2.84	"
22	5.45	0.69	3.76	"
10	1.45	0.69	1.00	"
7,8,17,20,14	23.61	0.45	10.62	"
½ bottle stow	7.85	0.15	1.18	"
1 gas cylinder	13.62	0.15	2.04	Both sides
3	25.65	1.09	27.96	Rhs
½ top shelf	4.09	0.94	3.84	Lhs
5	24.06	0.79	19.00	"
6,9,16,15	25.04	0.46	11.52	"
½ bottle stow	7.86	0.15	1.18	"
1 small gas cylinder	3.86	0.15	0.58	"
24	1.40	0.3	0.42	
Rack	30.87	0.46	14.20	Inc. pipework and cables
Totals	**226.50**		**145.94**	

COG for the rack is 0.64 m at 226.5 kg

12. Chemistry Rack – Summary of Attachments

Item 1 TECO 49 Ozone Reference
Instrument housing strapped to base tray using 2 of 14 swg (standard wire gauge) aluminium straps. Straps to be fixed to the base tray with 4 of 10:32 A102 bolts per strap.

Item 2 AL5002 CO Monitor
The instrument casing is bolted to the Rack Mounting Strips (RMS) on the rack using 4 x commercial M6 bolts into commercial cage nuts through internal lugs on the front of the instrument casing.
The instrument sits pm a flanged 16 swg 6082T6 aluminium shelf, this shelf being supported by and riveted to 2 x 6082T6 1” x 1” x 1/8” extruded aluminium angle side rails.
The side rails are fixed to the rear rack RMS via machined aluminium blocks, to which they are bolted with 2 x 10:32 A102 bolts. The blocks are fixed to the RMS using 4 x commercial M6 bolts into commercial cage nuts.
The forward face of the CO casing bears against 2 cleats made from 6082T6 1” x 1” x 1/8” extruded aluminium angle bolted to the side rails using 2 x 10:32 A102 bolts to resist forward movement. The casing is fixed to the cleats using 2 x 8:32 A102 bolts for restraint in upward movement.

Item 3 TECO 42 NO_x Monitor
Instrument housing strapped to base tray using 2 x 14 swg (standard wire gauge) aluminium straps. Straps to be fixed to the base tray with 4 x 10:32 A102 bolts per strap

Item 4 TECO 43 SO_2 Monitor
2 cleats made from 6082T6 1” x 1” x 1/8” extruded aluminium angle are bolted to the instrument casing using 2 per cleat of 10:32 A103 bolts. The cleats are fixed to the rear of the RMS using 2 x commercial M6 bolts into commercial cage nuts.
The instrument sits on a 14 swg shelf supported by 2 side rails of 2” x 1” x 1/8” 6082T6 aluminium extruded angle.
The rails are fixed to the rack at both forward and aft ends using 2 steel cleats per rail manufactured from the RMS section using 4 x M6 bolts into commercial cage nuts.
The instrument casing is bolted to a cleat at the forward end of the shelf using 3 A102 8:32 bolts. The cleat acts to restrain both forward and upward movement and is bolted to the shelf using 4 x 8:32 countersunk screws.

Item 5 – TECO 49C Ozone Monitor
2 cleats made from 6082T6 1” x 1” x 1/8” extruded aluminium angle are bolted to the instrument casing using 2 per cleat of 10:32 A103 bolts. The cleats are fixed to the rear of the RMS using 2 x commercial M6 bolts into commercial cage nuts.
The instrument sits on a 14 swg shelf supported by 2 side rails of 2” x 1” x 1/8” 6082T6 aluminium extruded angle.

The rails are fixed to the rack at both forward and aft ends using 2 steel cleats per rail manufactured from the RMS section using 4 x M6 bolts into commercial cage nuts.
The instrument casing is bolted to a cleat at the forward end of the shelf using 3 A102 8:32 bolts. The cleat acts to restrain both forward and upward movement and is bolted to the shelf using 4 x 8:32 countersunk screws.

Or

Instrument housing strapped to base tray using 2 x 14 swg (standard wire gauge) aluminium straps. Straps to be fixed to the base tray with 4 x 10:32 A102 bolts per strap

Item 6 CO Pump
The CO pump is fixed to the shelf using 4 x Mg commercial grade 8.8 hexbolts through rubber spacers.
The shelf is 1/8" 6082T6 aluminium bolted to 2 of 2" x 1" x 1/8" 6082T6 extruded side rails using 10 x A102 10:32 bolts.
The side rails are attached at both forward and rear RMS using a clear made from RMS steel section, bolted to the side rail with 2 x 10:32 A102 bolts and to the rack using 2 x commercial M6 bolts into commercial cage nuts per cleat.

Item 7 Ozone Pump
The pump is bolted to the shelf using 4 x M6 commercial grade 8.8 hexbolts into the pump casing.

Item 8 NO_x Pump
The pump is bolted to the shelf using 4 x M6 commercial grade 8.8 hexbolts into the pump casing.

Item 9 Sample Air Buffer Volume The Sample air buffer volume is mounted using a 18 swg aluminium strap, fixed with 4 x 6:32 A102 bolts to the shelf.

Item 10 Gas Purifier
The purifier is clamped to the rack diagonal using Tufnol blocks and A102-24D bolts. Drawing number ARAMRF 045002.

Item 11 Nafion 1
Teflon Perma pure drier cable tied to the rack mounting plates

Item12 and Item 14 N2MOUNT and STANDARD MOUNT
Clamped in 2 x aluminium brackets ¾" wide. Base of mounting bracket is fixed to the shelf with 2 x A102 10:32 bolts per bracket. Upper part of the clamp is attached to the lower portion using 2 x ¼"A102 bolts.
The cylinder is located at the forward end by a stopcleat of extruded aluminium angle ¼" thick. The cleat is bolted to the shelf using 3 x A102 10:32 bolts

The cylinder is located at the aft end by stopcleat of extruded aluminium angle 1/8” thick. The cleat is bolted to the shelf using 2 x A102 10:32 bolts

Item 13 Large gas cylinder mounting
The large gas cylinder, item 8.63 kg weight, the small gas cylinder weighs 4.54 kg.
They are mounted in aluminium vee blocks machined from 1” L168 plate, the blocks being bolted to the 5mm 6082T6 bottom shelf using 8 x 5/16” A102 bolts per cylinder mounting. The small cylinder mount has additional paxolin blocks to allow the straps to tension.
The cylinders are located in the vee blocks using 25 mm wide webbing straps, EUROWEB part no RL25 HDR
Refer to drawing number ARAMRF 045003
Lateral restraint is provided by extruded 6082T6 alumnium angle 2” x 1” x 1/8” cleat bolted to the shelf using 4 x ¼” A102 hexbolts at outboard end, and by a machined aluminium chair bolted to the shelf using 2 x 1/44” A102 bolts at the inboard end.

Item 15, 16   Gas Regulator #1 and #2
The regulators are mounted on the shelf using 2 x clamps per unit. The clamps are machined from Tufnol and are split horizontally. The upper part is retained using 2 x A102 10:32 bolts, the lower part is fixed to the shelf using 2 x A102 bolts. The clamps are fitted to each side of the regulator such that it is positively located.

Item 17 Gas Regulator
The regulator is bolted to an aluminium angle bracket1/4” thick using 2 x A102 10:32 bolts into the regulator body. The angle bracket is fixed to the shelf using 3 x 10:32 A102 bolts.

Items 21 and 22 Power Distribution Panel and Control PanelPOWERPANEL, CONTROLPANEL
The card frames are fixed to the rack RMS angle using 4 x commercial M6 screws into commercial cagenuts by means of the integral flanges on the casing. The 2 cardframes, one fitted at both forward and aft faces of the rack, are rigidly joined together by 2 siderails. These are made from 1”x1”x1/8” 6082T6 aluminium extruded angle section, fixed to the cardframes with 4 x 10:32 A102 bolts per rail (2 at each end).

Item 23 Small drier
A small plastic drier is attached to the shelf on the rack by large cale tie s through cable tie holders

Item 24 Large Drierite drier
The aluminium plate is bolted to the Rack Mounting Strips (RMS) on the rack using 4 x commercial M6 bolts into commercial cage nuts. The drier is fixed to the plate using large cable ties through cable tie holders bolted to the base plate with M6 bolts.

13. Power Use Summary Table

Item Name	Max Current A			Max Power W
	230 V 50 Hz	28 vdc	3 phase 400 Hz	
CO Monitor	-	4	-	112
CO Pump	1.8	-	-	460
Ozone Reference Monitor		-	-	
Ozone Pump	0.6	-	-	140
NOx Monitor	0.9	-	-	200
SO2 Monitor	0.45	-	-	100
NOx Pump	0.6	-	-	140
PC supplies	0.45	-	-	100
Ozone Monitor	0.65			155
Totals	**5.65**	**4**	**0**	**1407**

14. Core Chemistry Rack Appendices

1. Instrument descriptions
    a. Ozone Monitor
    b. Ozone Reference Monitor
    c. NOx Monitor
    d. SO2 Monitor
    e. CO Monitor
2. Pumps
    a. Ozone Pump
    b. NOx Pump
    c. CO Pump
3. Other Components
    a. Perma pure driers
    b. Inert Gas Purifier
    c. Stainless steel pipework
    d. PFA pipework
    e. Gas Pressure Regulators
    f. Gas Cylinders
    g. Drier
4. Drawing list
5. Safety information

1. Instrument Descriptions

1.1 Ozone Monitor
Thermo Electron (TECO) Model XXX

The model 49C features a symmetric dual cell U.V photometric design whereby a simultaneous zero and sample measurement result in increase ozone specificity.
A real-time cancellation of potential interferent species occurs via the cyclic process. In the beginning of the cycle, sample enters one cell the reference air (sample with the ozone catalytically removed) enters the second cell. Detectors then measure the light intensity transmitted through each cell. During the second half of the cycle, the roles of the two cells are interchanged by appropriate switching of the solenoid valves. Hence, any absorption of U.V. energy by a chemical species other than ozone is cancelled out. Additionally, this balanced optical system serves to correct for fluctuations in lamp intensity and improve response time. Temperature and pressure correction provides more precise ozone concentration measurements. Additionally,, a temperature-regulated lamp minimizes zero drift and maintains a high level of signal stability.
No ozone is produced by the instrument.

Specifications:	
Detection technique:	U.V. Photometric
Measurement:	Ozone (O3)
Lower limit of detection:	1.0 ppb (60 s averaging)
Ranges:	0 - 50; 100; 200; 500; 1000 ppb. Default 0 – 500 ppb
Sample Flow Rate:	2 LPM
Ozone catalytic converter:	Sealed unit containing copper screens coated with manganese dioxide, total amount of MnO2 less than 1 gm
Operating Temperature:	15 ° - 35 ° C (safe operation 5 ° - 40 °C)
Power Requirements:	210 – 250 VAC, 100 watts (Excluding External Pump)
Size and Weight:	16,75” (W) x 8.62” (H) x 23” (D), 53 lbs
Applications:	Measurement of Ambient Air on ground or on an aircraft

1.2 NOx Monitor
Thermo Electron (TECO) Model 42C

Chemiluminescence NO-NO2 –NOX Analyser capable of measuring oxides of nitrogen from sub parts per billion (ppb) to 100 parts per million (ppm).
User front panel interface consists of a Vacuum Fluorescent Display and function keys. User programmable software capabilities allow individual measurement range settings to be stored in the memory for subsequent recall and NO, NO2, NOx averages to be stored. Teco’s model 42C utilizes a core microprocessor in conjunction with a dedicated communications processor and electronic transducer.

Optical system:

Sample gas is drawn into the Model 42C through a particulate filter, a capillary and then to a solenoid valve. The valve routes the sample either directly to the reaction chamber (“NO” mode) or through the NO2 to NO converter and then to the reaction chamber (“NOx” mode). There the NO reacts with ozone to produce a characteristic chemiluminescence.
The ozone is produced in an “ozonator” giving a concentration of approx. 5 % in the exhaust air, maximum flow of 1.5 LPM.

The Model 42C is of a single chamber, single photomultiplier tube design and automatically cycles between the NO and NOx modes. Signals form the photomultiplier tube are conditioned and then fed to the microprocessor where a sophisticated mathematical algorithm is used to calculate three independent outputs: NO, NO2 and NOx.

Specifications:
TECO 42C Trace Level

Detection technique:	Chemiluminescence
Measurement:	Continuous NO, NO2 and NOx analysis
Ranges:	0 – 5, 10, 20, 50, 100 and 200 ppb
Linearity:	+/- 1% of full scale
Zero noise:	25 ppt RMS (120 s averaging time)
Lower Detectable Limit:	50 ppt (120 s averaging time)
Zero drift (24 hour):	Negligible
Span Drift (24 hour):	+/- 1% of full scale
Sample flow rate:	1 LPM
Operating Temperature:	15 ° - 35 °C (safe operation 5 ° - 40 °C)
Power Requirements:	210 – 250 VC, 100 watts (Excluding External Pump)
Size and weight:	16.75” (W) x 8.62” (H) x 23” (D), 53 lbs
Applications:	Ambient air sampling on ground and in aircraft

1.3 Model 43C Sulphur Dioxide SO2 Analyser
Thermo Electron (TECO) Model 43C
Pulsed florescence SO2 analyser uses pulsed fluorescence, enhanced electronic’s package and user interface.

Optical System:
A pulsed U.V. light source, reflective wavelength filtering, circular baffling of stray light and lamp excitation energy feedback control. The pulsing of the U.V. source lamp serves to increase the optical intensity whereby a greater U.V. energy output and lower detectable SO2 concentration are realised. As an added benefit, the lamp operating life is extended.

Reflective bandpass filters, as compared to commonly used transmission filters, are less subject to photochemical degradation and more selective in wavelength isolation. This results in both increased detection specificity and long term stability. The minimisation of stray light entering the photomultiplier tube is achieved through implementation of a circular baffle prior to the instrument reaction chamber.

Specifications:

43C Trace Level

Detection Technique:	Pulsed fluorescence
Measurement:	Continuous SO2 analysis
Ranges:	0 –10, 20, 50, 100, 200, 500, 1000 ppb
Linearity:	+/- 1% of full scale
Zero noise:	0.1 ppb RMS (10 s averaging time)
Lower Detectable Limit:	0.2 ppb (10 s averaging time)
Sample flow rate:	0.5 LPM
Operating Temperature:	20° - 30 °C (safe operation 5 ° - 40 °C)
Power Requirements:	210 – 250 VC, 100 watts
Size and weight:	16.75” (W) x 8.62” (H) x 23” (D), 44 lbs
Applications:	Ambient air sampling on ground and in aircraft

1.4 CO Monitor

AEROLASER

The measuring method is based on the fluorescence of Coin the VUV at 150 nm. The excitation light comes from a cw-CO2/Ar lamp. The fluorescence in the wavelength range between 160 nm and 190 nm is detected by a VUV photomultiplier followed by a fast counter. The basic principle is described in detail in **“AN improved fast-response VUV fluorescence CO instrument”, Ch. Gerbig et al, J. *Geophys. Res*. 104, D1, (1999) 1699 - 1704**

Specification

Measuring range:	up to 1000,000 ppbV
Detection Limit:	<2.0 ppbv (10s)
Sensitivity:	about 30 to 80 counts / ppbV
Time constant:	about 0.1 s (10 – 90 %), signal delay 2 s
Background check:	internal zero trap
Calibration:	CO gas standard
Digital signal output:	RS232 interface, LAN interface
Interface parameter:	32400, 16200, or 9600 baud
	No parity
	8 data bits
	1 stop bit
Dimensions:	Length 49.6 cm
	Width 48.8 cm
	Height 17.7 cm
	Weight20 kg
Power Requirements:	18 to 32 Volt DC, max 3.8 Amp at 24 Volt

The instrument consists of a resonance lamp excited by an RF discharge, an optical filter for selection of the appropriate wavelength interval around 150 nm, and a fluorescence chamber. The emission of the lamp is collimated within the optical filter to a parallel beam of 150 nm light, using CAF2 lenses, and then focussed into the fluorescence chamber, where the fluorescence from the CO is viewed at right angles by a photomultiplier (PMT) with Suprasil pre-optics. The optical filter is completely sealed and gently flushed with dry N2.

The discharge of the CO resonance lamp is imaged into the fluorescence chamber by means of two Caf2 lenses. Then two dielectric mirrors in the parallel part of the light beam, provide the spectral band path (bandwidth of 8 nm full width at half maximum at approximately 150 nm).

The instrument consists of a resonance lamp excited by a RF discharge, an optical filter for selection of the appropriate wavelength interval around 150 nm, and a fluorescence chamber. The emission of the lamp is collimated within the optical filter to a parallel beam of 150 nm light, using CaF_2 lenses, and then focused into the fluorescence chamber, where the fluorescence from CO is viewed at right angles by a photomultiplier (PMT) with Suprasil pre-optics. The optical filter is completely sealed and gently flushed with dry N_2 (purity better than 5.0 and filter to compress organic substances).

The discharge of the CO resonance lamp is imaged into the fluorescence chamber by means of two CaF_2 lenses. Then two dielectric mirrors in the parallel part of the light beam, provide the spectral band path (bandwidth of 8 nm full width at half maximum (FWHM) at approximately 150 nm; see Fig. 1). The optical filter is continuously flushed with N_2(6.0) which is necessary to avoid absorption of radiation in the Schumann-Runge continuum of molecular oxygen and from impurities, in particular CO. This only requires a flow of *ca.* 20 ml/min N_2 as the volume is very small. The optical filter is made from Al covered with a black coating for reduction of stray light.

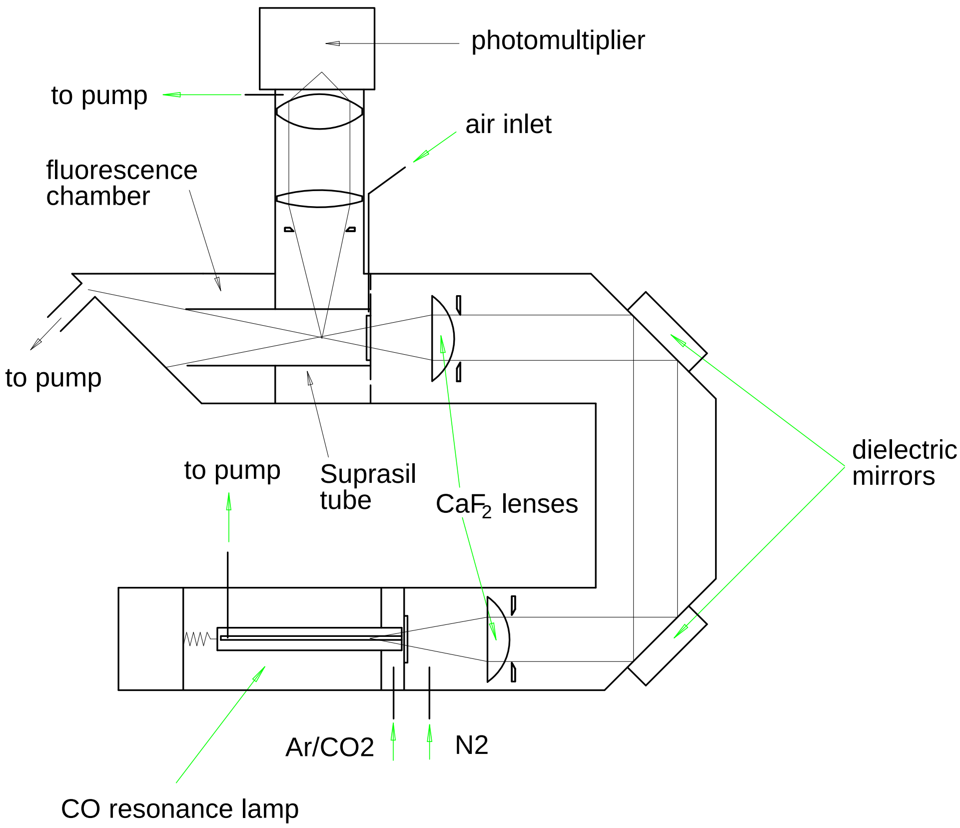

Fig. 1: Schematic diagram of the AL5002 CO monitor.

In order to enhance the exchange rate of the sample gas within the fluorescing volume, a high-quality quartz tube was installed in the fluorescence cell (see Fig. 1), coaxial with the optical axis of the exciting radiation. A homogeneous flow through the quartz tube, without reducing the time response due to the dead volume, is achieved by feeding the sample gas into the tube via four small orifices around the window between the optical filter and the fluorescence chamber. The air is vented into the fluorescence chamber, which is connected to the pump at the end of the light trap and at the PMT flange, in order to provide a well-defined air flow.

The flow system, shown in Fig.2, consists of 3 parts, the gas supply for the lamp, the flow system for flushing N_2 through the monochromator and the gas processing system for the measuring gas. For the regulated operational gas flow of the lamp, a mixture of Ar (6.0) and 0.25 % CO_2, is used. Contamination of this gas flow with water can reduce the intensity of the VUV lamp in the wavelength range of 150 nm, so it is necessary to use high purity Ar. The optimum operational lamp pressure is at about 6 to 7 mbar.

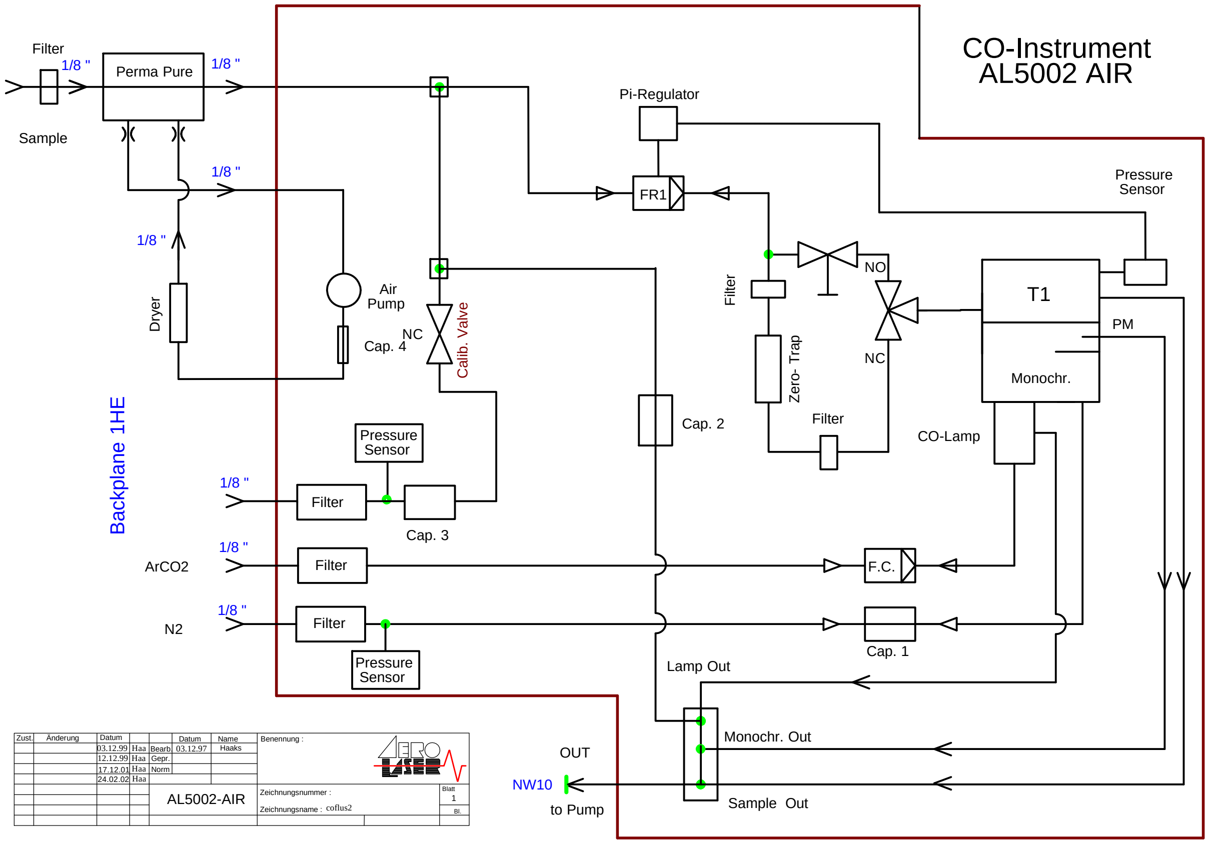

Fig. 2: Flow diagram of the fast AL5002 CO monitor

As the method has a slight sensitive to water, the measuring gas has to be dried before it enters the fluorimeter. The gas is circulated through an integrated NAFION dryer containing a small pump and a desiccant; molecular sieve (1 nm) is used as the desiccant with a thin layer of DRIERITE as indicator.

The pressure inside the fluorescence cell must be kept constant regardless of the flow through the lamp and the outside air pressure. A sensitive pressure regulator, with a pressure sensor (max 10 Torr), a control valve and a proportional integrated controller, inside the instrument has been adjusted to maintain a constant pressure of 6 to 7 mbar, regardless of the external pressure. The internal pressure can be altered on the front panel of the instrument or via an external computer.

2.1 Ozone pump

Vacuum pump with solid Teflon Resin Heads and Teflon coated diaphragms
Type No. 30 N726.1.2FTP Parallel head Teflon/Kalrez/Teflon 25 x 20 x 18
Pump motor 230 vac 500mA run 1 Amp max start 1450 rpm
Mass moment of inertia approx. 0,01 kgm2 for the motor and the pump combined.

Built from premium corrosion-resistant Teflon ND Kalrez resins, these pumps handle the harshest gases and vapours found in the laboratory.

They are available in either single or parallel head or two – stage configurations. The single and parallel head models provide output pressure up to 20 psig, 50 Torr Vacuum, and transfer most corrosive gases and vapours found in the lab. The two stage model is designed to achieve a deeper vacuum. All are supplied with ¼” hose connectors.

Ozone pump supplied by
KNF Neuberger UK Ltd., Avenue 2, station Lane industrial Estate, Witney, Oxfordshire, OX28 4FA
Tel: 01993 778373

2.2 NOx Pump
Vaccuum pump with aluminium heads and Teflon coated diaphragms
Type No. MPU 485 No26.3-9.91
Pump motor 230 vac 500 mA run 1 Amp max start 1450 rpm
Mass moment of inertia approx. 0,01 kgm2 for the motor and the pump combined.

General description as Ozone pump.
Supplied as part of the TECO NOx monitor

2.3 CO pump

Four stage diaphragm pump
Type No. MV 2 stage
Pump motor 230 V (~60Hz) 0.6mbar 1.8A 1800 rpm

VACUUBRAND diaphragm pumps are totally oil free, mechanical vacuum pumps. They can be used for a multitude of applications of vacuum generation in laboratories and process plants.
They offer low vacuum down to 80 mbar (one-stage pumps), 9 mbar (two-stage pumps) 2 mbar (three- stage pumps) or 0.6 mbar (four-stage pumps). Optimised kinetics for minimum work and wear of the diaphragm result in high reliability, low scuffing, long life and low noise level of the diaphragm.

Pump supplied by
VACUUBRAND GMBH + CO KG
Alfred-Zippe Str 4
D-97877 Wertheim
Germany
Tel +49 9342 808 0

3.1 Perma pure driers

Perma pure MD series gas dryers are single tube Nafion driers designed for high performance gas monitoring applications. These dryers can be used to dry a sample to as low as –45 °C without removing sample analytes. The perma pure dryers consist of a single nafion tube housed within a flexible plastic tube shell. Sample gas flows within the Nafion tube whilst the water vapour absorbs into the nafion membrane tube walls and is removed. A dry purge gas with the shell that flows countercurent to the sample carries moisture away. Purge gas should be instrument quality air or nitrogen flowing at two to three times the sample flow rate.

On the chemistry rack the dryer for SO_2 is connected to the sample line as close as possible to the air sample pipe. The purge gas is produced by reducing the pressure in the outer sheath with a connection to the NO_x vacuum pump.

The ozone Nafion is internal to the instrument.

The CO Nafion is situated on the rack and purge gas created by the instrument and recycled using the small drier attached to the rack.

Supplied by
Permapure PO Box 2105, 8 Executive Drive, Toms River, NJ 08754

3.2 Inert Gas Purifier

Model SS-400KGC-I-2S

Inert Gas Purifier Series

Features

- Purifies Nitrogen gas
- Removes O_2, CO, CO_2, H_2, H_2O and Non-methane hydrocarbons
- <1ppb Outlet purity
- Nickel Metallic Media Type
- Operates at ambient temperature

-40 to 150F (-40 to 65 °C)

- No heat or power required
- Does not release hydrocarbons
- Lowest cost of ownership

Body Specifications

- Max Flow 5 LPM
- Max operating pressure = 700 psig
- Max Differential pressure = 200 psig
- Filtration 20.0 micron
- Fitting type Compression 1/8” inlet and outlet
- Materials of construction 304 SS
- Internal Surface Finish Mill Finish
- Leak Rating 1 x 10-9 atm cc/sec
- Approximate Weight 1.7 kg
- Dimensions 525 mm x 38.1 mm

Appendix 1
Core chemistry – Pre flight instructions

1. **Turn on the gases (make sure taps are open on the regulators)**
    - CO2/Ar – pink cylinder on bottom shelf, open valve 1 anticlockwise
    - N2 – small cylinder with black top on bottom shelf, open valve 2 anticlockwise
    - CO – small cylinder with green top on middle shelf, open valve 3 anticlockwise
2. **Open needle valves on regulators**
    - Make sure needle valve is open on CO2/Ar regulator, open valve 4 anticlockwise
    - Make sure needle valve is open on Nitrogen regulator, open valve 5 anticlockwise
3. **SSP CBs**
    - 28 V push push ON
    - 230 V ac push push ON
    - 115 V 3 phase push push ON
4. **Pipework connections off rack to ASP and exhaust**
    - Check sample lines for NOx and Ozone connected – if not inform operator
5. **CBs on input panel**
    - 115 V 3 phase push push ON
    - 230 V ac push push ON
    - 28 V push push ON
6. **Check outlet pressures**
    - Check that the outlet pressure for CO2/Ar is between 2 and 2.5 bar, valve 6
    - Check that the outlet pressure for Nitrogen is between 2 and 2.5 bar, valve 7
    - Check that the outlet pressure for CO standard is between 3 and 3.5 bar, valve 8

    NB) Turn clockwise to increase the outlet pressure
7. **Switch on NO_x and Ozone pumps**
    - Ozone switch up indictor lamp on
    - NOx switch up indicator lamp on
8. **Switch on instruments on front panel of each instrument**
    - Ozone (TECO 49)
    - NO_X (TECO 49)
    - SO_2 (may not be on aircraft)
    - CO (AeroLaser) – make sure gases have been on for at least 5 minutes
9. **Basic front panel indications on instrument**
    - Ozone – LED panel start up sequence
    - NO_X – LED panel start up sequence
    - SO_2 – LED panel start up sequence
    - CO LCD display shows start up sequence

10. **Check flows on CO instrument**.

- On the CO instrument press F3, the flows and pressures should read approximately as follows;

Flow lamp	:	~ 40 ml/min
Press. Monocr	:	~ 5 bar
Press. Cell	:	~ 10.0 Torr
Press. Cal. Gas	:	~ 4.25 bar

If there is a low flows it may be that the needle valves are still shut, the cylinder has not been turned on or the pressure adjusting knob is turned out to zero. Labels in front of the regulators show what pressure these should be set to. If the flows on the instrument still do not change, switch off instrument. DO NOT USE INSTRUMENT INFORM THE OPERATOR WHEN THEY ARRIVE.

11. Switch on the CO pump

- CO - switch up - indicator lamp on

  The flows and pressure should now read as follows;

Flow lamp	:	~ 40 ml/min
Press. Monocr	:	~ 5 bar (2 bar on reg)
Press. Cell	:	~ 7.5 Torr
Press. Cal. Gas	:	~ 4.25 bar

12. Switch on the CO lamp

- Wait 10 - 15 minutes after gases have been switched on before switching on the CO lamp
- Press F2 to show counter output as the lamp is switched on this should increase. To switch the lamp on pull up the switch on the front of the CO instrument to show lamp has struck. If after a minute there is no significant increase in the numbers switch lamp off and restart the lamp. Repeat if necessary up to 5 times
- If lamp fails to light after 6 attempts switch off instrument DO NOT USE INSTRUMENT AND INFORM OPERATOR WHEN THEY ARRIVE

Appendix 2

Operation of the Core Chemistry Rack

Pre-flight – is carried out by preflighter

13. Zeros

- Carry out zeros on NO_x, SO_2 and Ozone using the scrubber, make a note of the zero values
- Turn the CO zero valve
  Press SHIFT F3, VALVE
  The screen will read

  ZERO VALVE OFF

  Press OFF and the screen will read

  ZERO VALVE ON

- leave it on for about 10 minutes. Make sure you switch this off by pressing ON else the valve will not turn and the instrument will continue zeroing

14. WAS canisters

- The WAS canisters should be connected by the WAS operator. However the core chemistry operator should check the hold is tidy and ready for flight

15. TDLAS switch on

- Check that the gas inlet valve is closed (Yellow - vertical position)
- Switch on SSB (these may already be on)
- On rear of rack push in the breakers for 230V and 28V and the two breakers labelled TDL and TDLAS
- Open the GAS OUTLET VALVE (red – horizontal)
- Power up laptop, login "tdlas", password "tdlas"
- Select paths to store the data, this should be a folder on the desktop for the project. Within the folder make a new folder for the flight number. Save all three data formats in the same folder
- After about 10 minutes turn on the pump
- After a further ten minutes open the GAS INLET VALVE (Yellow – horizontal position)

Prior to take off

Close GAS INLET VALVE on TDLAS (yellow) and turn off TDLAS pump

Switch off the CO monitor during power changeover but make sure it is off the minimum time possible as the lamp cools down rapidly.

During flight

TDLAS

Turn on the pump and open the gas inlet valve, make sure the laptop screen is up
Check at regular intervals that the instrument is still working

Prior to landing shut GAS INLET VLAVE and turn off pump

CO

The CO requires calibrating at each change of altitude. However, if at low level but changing altitudes a quick check can be performed to see if a calibration is required.

Quick check calibration

Press SHIFT F3, VALVE

The screen should read

CALIBRATION VALVE OFF

Press OFF
The calibration valve will turn and the screen will read

CALIBRATION VALVE ON

If the concentration at the top of the screen reads between 510 – 520 ppbV then a full calibration is not required. Turn the valve by pressing on so the screen reads

CALIBRATION VALVE OFF

If at low level a full calibration should be carried out at least every hour.

Normal Calibration

1. Press SHIFT + F5
2. Choose calibration
3. Chose start calibration
4. Choose yes

The calibration procedure should take approx. 3 minutes.

If a very short run or if the aircraft is in an interesting feature then measurements take priority over calibration. If in doubt ask the flight or mission scientist if you are clear to do a cal

A log should be taken noting down all calibration constants on the CO (F4), lamp gas flows (F3) , cell pressure (F3) and lamp temperature (F3).

O3

The Ozone flows should be noted whenever a CO calibration is carried out, these are shown on the flowmeters on the front of the instrument

NO_x

The NO_x sample flow and ozonator flow should be noted whenever a CO calibration is carried out
Press MENU
Scroll down to DIAGNOSTICS, press ENTER
Scroll down to FLOWS, press ENTER
The flows will be shown, to return to the main screen press RUN

SO_2

The SO_2 sample flow should be noted whenever a CO calibration is carried out
Press MENU
Scroll down to DIAGNOSTICS, press ENTER
Scroll down to FLOWS, press ENTER
The flows will be shown, to return to the main screen press RUN

Post flight

Normal shutdown for core chemistry rack

- Turn off the CO monitor lamp
- Switch off three pumps
- Close tap on each regulator
- Close 3 cylinder main valves
- Turn off the NO_X, O_3, SO_2 (if on the aircraft) and CO monitors on front panel
- Close down programs and switch off lap top PC
- Pull 3 CBs on input panel
- Pull CBs on SSP

Gases

Check the pressure left in all the cylinders, should a cylinder need changing do it post flight as the pre- flighter will not have time to change cylinders. **The Nitrogen cylinder should have at least 20 bar left in it, if not it should be refilled**

The WAS operator may give you the WAS cylinder to refill – this should be done by a trained member of FAAM before the next flight.

Normal shutdown for TDLAS

- Copy data to memory stick
- Power down laptop
- Turn off breakers
- Close GAS OULET VALVE

Emergency shut down procedures

1. Pull all 3 CBS on input panel
2. Close gas cylinder main valves
3. Inform flight manager

Additional notes for operating personnel

Each instrument indicates internal fault conditions on the front panel displays. Make a note of any of these in the core chemistry log.
Lap top PC is for displaying networked data and is not required for rack operation

Possible minor faults

1. Pump faults
   Excessive noise or vibration. Overheating
   Switch off pump. Switch off associated instrument.
   Make preliminary investigation depending on fault condition indicated. Make complete notes in log. Do not switch back on unless certain that fault condition is cleared. Inform flight manager of instrument status
2. Gas system faults
   Incorrect flows indicated on instrument (see above).
   Excessive gas usage – indicates a possible leak. Investigate check connections. If difficult to reseal, close off main cylinder valve and close down CO instrument. Other instruments can continued to be used.
3. Electrical faults
   CB tripped. Inspect cables and associated instrument. If no obvious fault reset CB ONCE. If fault still present shut down associated instrument and pumps. Inform flight manager.

Contact

If you experience problems with any of the core chemistry instrumentation please inform Ruth Purvis (01234 754534, **rupu@faam.ac.uk**)