



COSAMS Generic

User Manual

Commercial in Confidence

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Warnings, cautions and notes

Warnings and Cautions are used in this Manual to highlight potential hazards and safety risks. Notes are used to provide supplementary information that is not hazard-related.

-  **WARNING:** THIS INDICATES A POTENTIALLY HAZARDOUS SITUATION THAT, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY.
-  **CAUTION:** THIS INDICATES A POTENTIALLY HAZARDOUS SITUATION THAT, IF NOT AVOIDED, COULD RESULT IN EQUIPMENT DAMAGE OR LOSS OF DATA.
-  **NOTE:** THIS INDICATES INFORMATION THAT IS CONSIDERED IMPORTANT BUT IS NOT HAZARD RELATED.

Safety information

Please read this manual prior to installing and using the Analox COSAMS, paying particular attention to the following safety information:

- ⚠ WARNING: DISCONNECT THE POWER SUPPLY BEFORE PERFORMING ANY MAINTENANCE WITHIN THE CABINET.**

- ⚠ WARNING: HIGH PRESSURE GAS SUPPLY MUST NOT BE APPLIED TO EITHER OF THE COSAMS GAS PORTS. TO DO SO MAY RESULT IN DAMAGE TO THE COSAMS SYSTEM AND THE POSSIBLE EMISSION OF PROJECTILES. GAS PRESSURE AT THE INLET PORT MUST NOT EXCEED 500HPA (GAUGE PRESSURE). DO NOT OBSTRUCT THE EXHAUST PORT.**

- ⚠ WARNING: THE COSAMS CONTAINS A SMALL QUANTITY OF CATALYST WHICH MUST BE REPLACED DURING ROUTINE SERVICING. THIS MATERIAL MAY CAUSE IRRITATION OF THE EYES, NOSE, THROAT AND SKIN BUT UNDER NORMAL CIRCUMSTANCES AN OPERATOR/TECHNICIAN WILL NOT COME INTO CONTACT WITH THIS MATERIAL. MATERIAL SAFETY DATASHEETS (MSDS) ARE INCLUDED IN THE APPENDICES.**

- ⚠ WARNING: SOME COMPONENTS OF THE GFC CO SENSOR, MOUNTED WITHIN THE COSAMS CABINET, ARE CONTROLLED TO 50°C DURING NORMAL OPERATION OF THE SENSOR. THE SENSOR SHOULD BE ALLOWED TO COOL A LITTLE BEFORE HANDLING.**

1 Introduction

This manual details installation, operation and maintenance of the Analox COSAMS carbon monoxide (CO) sensor, developed for the submarine atmosphere monitoring system.

Each COSAMS indicates the local CO concentration on a colour LCD and transmits a corresponding 4-20mA signal to the submarine's Central Air Monitoring System.

The COSAMS user interface permits calibration of the sensor and may be used to provide a local visual alarm, if desired.

2 Modification state control

Each instrument is fitted with a serial number plate, as shown below:

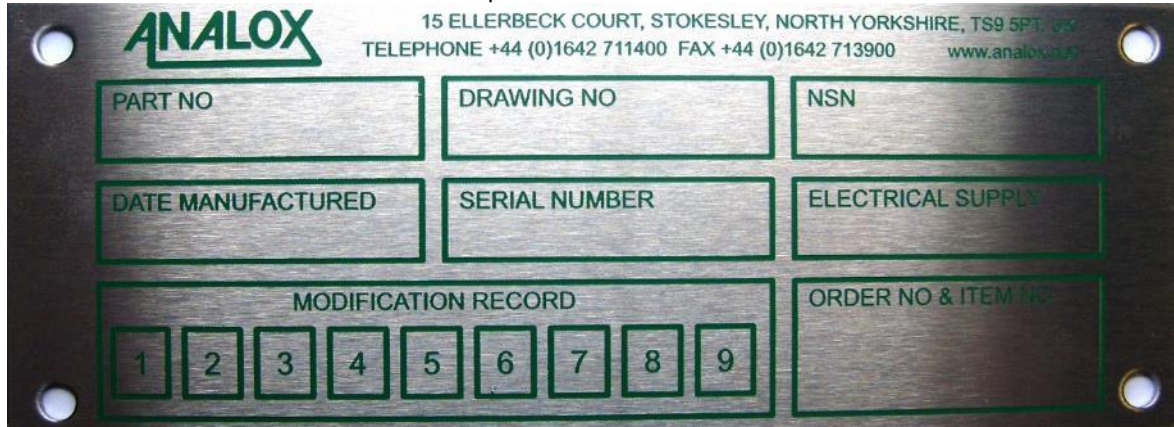


Figure 1 Modification state label

The first COSAMS delivered will initially have no modification numbers crossed out, this is interpreted as "Modification State 0".

As design changes are made that affect the form or function of the instrument, the *Modification Record* boxes will be used to track changes made to individual units. For example, as an instrument receives the first authorised modification it will have the '1' box crossed out, signifying that it is now at modification state 1. Design changes that are applied to ALL delivered instruments in a controlled and timely manner may be done without updating the modification record; the purpose of the modification record is to signify the differences between instruments.

Modification state	Date authorised	Details
0		First article delivery
1		
2		
3		
4		
5		
6		
7		
8		
9		

Table 1 Cabinet modification state

The baseplate is fitted with a modification state label as shown below:

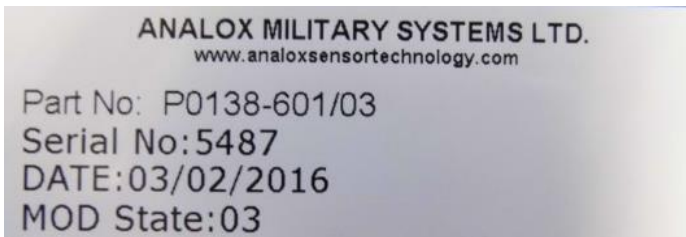


Figure 2 Baseplate modification state label

As design changes are made that affect the form or function of the instrument, the *Modification Record* boxes will be used to track changes made to individual units. For example, as an instrument receives the first authorised modification it will have state '01' after MOD State, signifying that it is now at modification state 1. Design changes that are applied to ALL delivered instruments in a controlled and timely manner may be done without updating the modification record; the purpose of the modification record is to signify the differences between instruments.

Modification state	Date authorised/DCN No	Details
0		First article delivery
1		
2		
3		

Table 2 Baseplate modification state

3 System checklist





Each system, suitable for fitting out one submarine, comprises the following items:

Item	Description
1.	COSAMS instrument
2.	Power input connector
3.	Signal output connector
4.	Enclosure locking key
5.	2m length of calibration sample tube
6.	USB lead
7.	COSAMS software CD
8.	User Manual
9.	Test Certificate/statement of Conformity

Table 3 System checklist

4 Transport and storage considerations

To avoid equipment damage when storing or transporting a COSAMS unit it must always be packed in suitable transport packaging.

-  **CAUTION:** WHEN STORING OR TRANSPORTING A COSAMS UNIT IT MUST ALWAYS BE PACKED IN SUITABLE TRANSPORT PACKAGING.
-  **CAUTION:** PRIOR TO POWERING UP THE INSTRUMENT, IT SHOULD ALWAYS BE ALLOWED TO RETURN TO ITS OPERATING TEMPERATURE RANGE AND ANY CONDENSATE THAT MAY HAVE FORMED MUST BE ALLOWED TO EVAPORATE.
-  **NOTE:** DETAILS OF PERMISSIBLE STORAGE TEMPERATURE, HUMIDITY AND PRESSURE RANGES CAN BE FOUND IN SECTION 15, ENVIRONMENTAL SPECIFICATIONS.
-  **NOTE:** THE COSAMS WILL REQUIRE CALIBRATION AFTER TRANSPORT OR STORAGE.

5 Installation details

5.1 Overview

The COSAMS electronics are housed in a custom-made cabinet fabricated from 5000 series aluminium. External surfaces are painted with RAL7001 (silver grey) epoxy paint to DTD5555A (MIL-22750F) with low-profile spatter finish.

The cabinet has two lugs per side for direct-mounting to a bulkhead.

The enclosure achieves a minimum ingress protection of IP44.

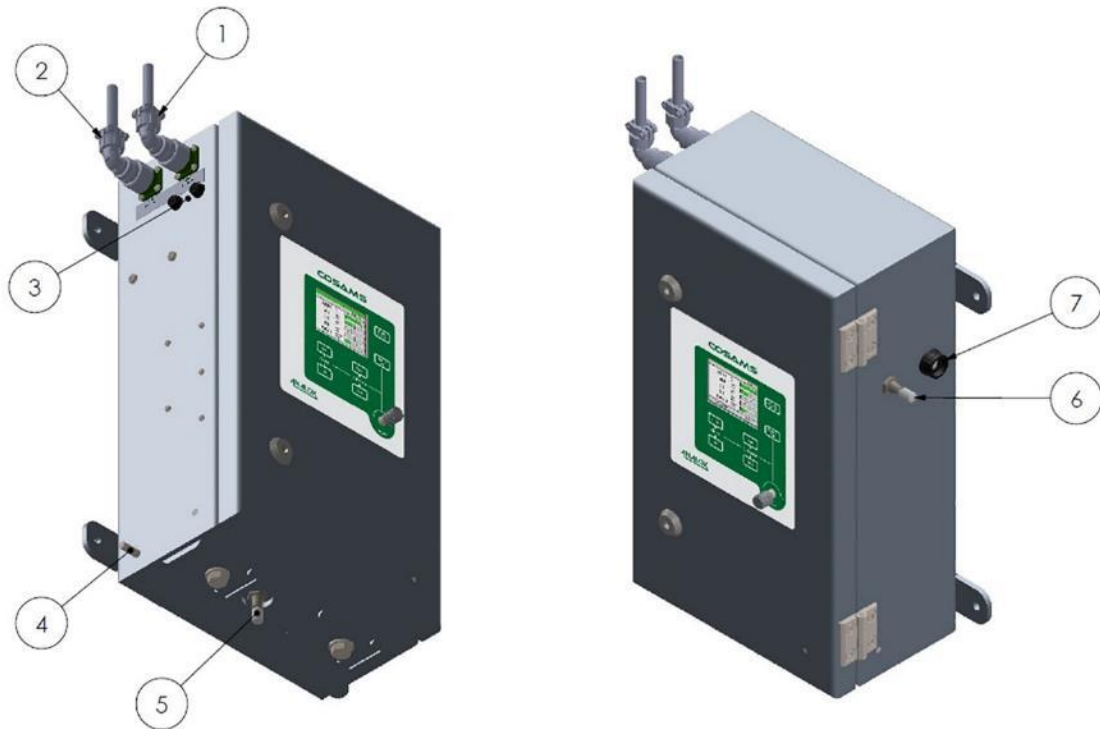


Figure 3 COSAMS overview

Access is required from the left hand side for the electrical connections:

- power input (1)
- 4-20mA signal output (2)
- earth stud for equipotential bonding to the submarine hull (4)

Two waterproof fuse holders are also accessed from the left hand side (3) (DC variant).

The fuse holders are located internally for the AC variant.

Gas sample is drawn through an inlet (5) in the cabinet's base and exhausts out of the right hand side (6). A water-proof breather port (7) is also mounted on the right hand side to ensure that cabinet internal pressure tracks submarine compartment pressure.

Push-fit sinters are supplied with the COSAMS and one should be fitted in both the inlet and exhaust ports to pre-filter the sample and guard against water entry in the event of splashing.

Access to the cabinet base and right-hand side will be required to maintain the pre-filters and also when applying calibration gas to the COSAMS.

5.1.1 Tools/consumables required for installation

Installation of the hardware is possible using standard hand tools (i.e. spanners/socket set, screwdrivers, hex keys, soldering iron, etc.); no special tools or consumables are required.

Upon installation, the system should be calibrated according to section 8.

5.2 Mechanical installation

5.2.1 Mounting COSAMS



Figure 4 Mounting arrangement

M8 hardware should be used to securely bolt the COSAMS using the two mounting lugs protruding from either side; the relative positions of the rectangularly arranged mounting holes (330 x 369mm centres) are indicated in Figure 5

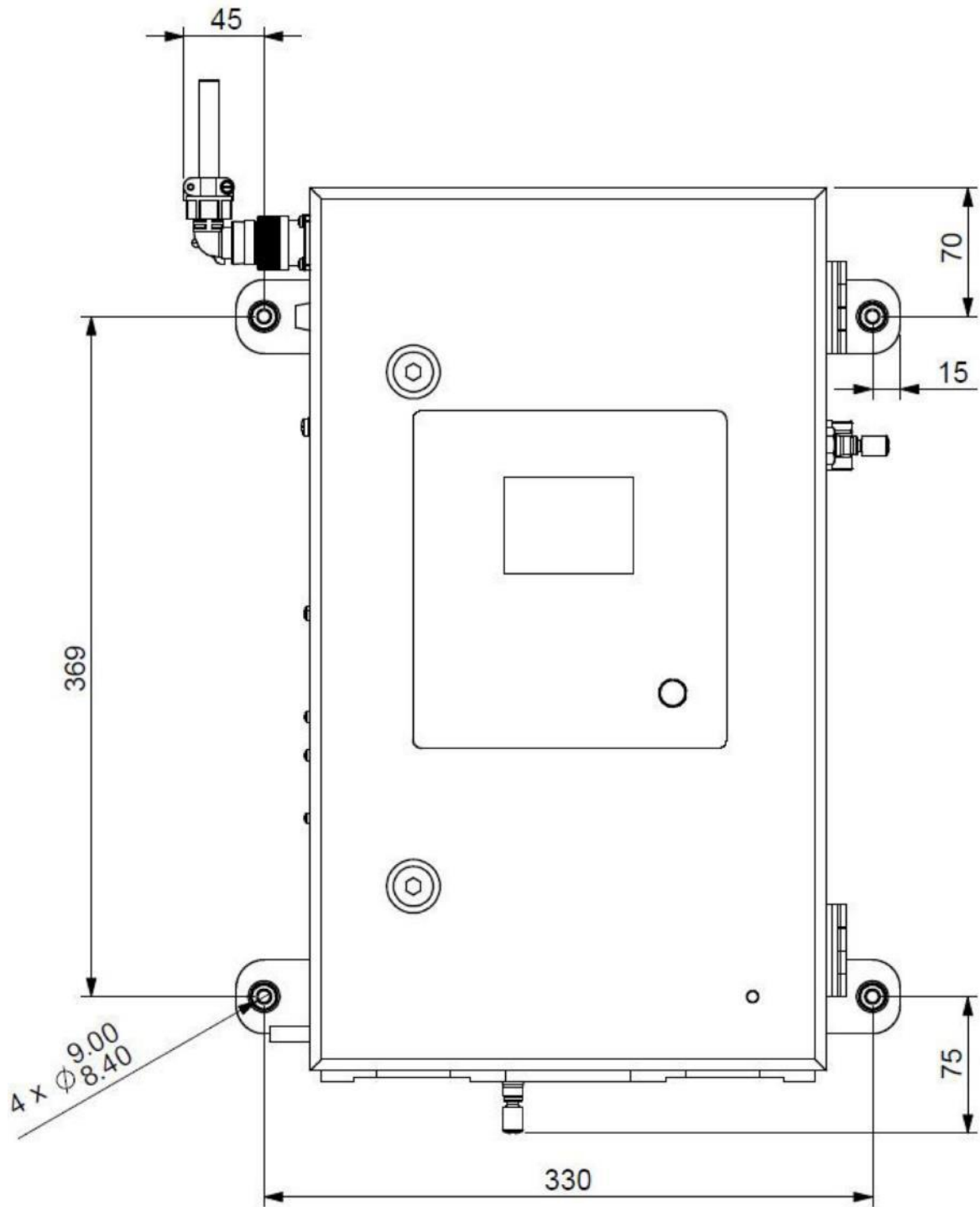


Figure 5 Relative positions of COSAMS mounting holes

5.3 Electrical installation

Three external electrical connections are required to the COSAMS:

- power input
- signal output
- equipotential bonding strap

The COSAMS cabinet has a 3-way, male, chassis-mounted plug for connection to an 85-264Vac, 47-63Hz supply; maximum power consumption is 90W, or a low voltage DC supply; maximum power consumption is 150W. A mating connector (3-way, female, cable-mounting socket) is supplied with COSAMS.

 **NOTE: THE DESIRED SUPPLY VOLTAGE IS FACTORY FIT ONLY AND SHOULD BE DECIDED PRIOR TO ORDERING.**

A 3-way, female, chassis-mounted socket provides connection to the 4-20mA output signal and a mating connector (3-way, male, cable-mounting plug) is supplied with COSAMS.

5.3.1 AC Cable identification

AC version cables are to be terminated as follows:

	Connector description	Manufacturer's part number
	VG95234/MIL-STD-5015C 3-way cable female socket, 90°	ITT Cannon CB8U14S-7SS
	VG95234/MIL-STD-5015C 3-way cable male plug, 90°	ITT Cannon CB8U14S-7PS

Table 4 Connector details

	Pin no.	Function	Cable core
	1	L1	Installer to advise
	2	L2	
	3 [refer to the CAUTION below]	Earth	Not connected
	Body	Earth	Screen
<hr/>			
	1	Signal +	Installer to advise
	2	Signal -	
	3	Not connected	Not connected
	Body	Earth	Screen

Table 5 Connector pin-out

⚠ CAUTION: NO CONNECTION IS TO BE MADE TO PIN 3 OF THE CABLE MOUNTED POWER CONNECTOR. PIN 3 OF THE COSAMS CABINET-MOUNTED PLUG IS CONNECTED TO THE CABINET BODY IN ORDER TO MAKE PROTECTIVE EARTH CONNECTION DURING FACTORY SET UP AND TESTING.

5.3.2 DC Cable identification

DC version cables are to be terminated as follows:

	Connector description	Manufacturer's part number
	VG95234/MIL-STD-5015C 3-way cable female socket, straight	ITT Cannon CB6U16-10SS
	VG95234/MIL-STD-5015C 3-way cable male plug, straight	ITT Cannon CB6UE14S-7PS

Table 6 Connector details

	Pin no.	Function	Cable core
	A	+VE	Installer to advise
	B	-VE	
	C [refer to the CAUTION below]	Earth	Not connected
	Body	Earth	Screen
	A	Signal +	Installer to advise
	B	Signal -	
	C	Not connected	Not connected
	Body	Earth	Screen

Table 7 Connector pin-out

CAUTION: ***NO CONNECTION IS TO BE MADE TO PIN 3 OF THE CABLE MOUNTED POWER CONNECTOR. PIN 3 OF THE COSAMS CABINET-MOUNTED PLUG IS CONNECTED TO THE CABINET BODY IN ORDER TO MAKE PROTECTIVE EARTH CONNECTION DURING FACTORY SET UP AND TESTING.***

5.3.3 Signal output

An Analox SDA output module controls a 4-20mA analogue signal proportional to the perceived CO concentration over the range 0-200ppm. The module is configured to operate in active mode and compliance is maintained for loop resistances up to 500Ω.

The analogue output is set to ~2mA during warm-up and in the case of a fault condition being detected.

During the course of an auto-zero operation the 4-20mA output is maintained at a value corresponding to the CO measurement recorded immediately prior to initiating the auto-zero.

5.3.4 Equipotential bonding strap

A suitable flexible bonding strap must be attached to the COSAMS M8 earth bonding stud. This will be the means of achieving HF bonding according to MIL STD 1310.

6 Technical description

Figure 6 shows the COSAMS pneumatic arrangement and Figure 7: the internal electrical arrangement.

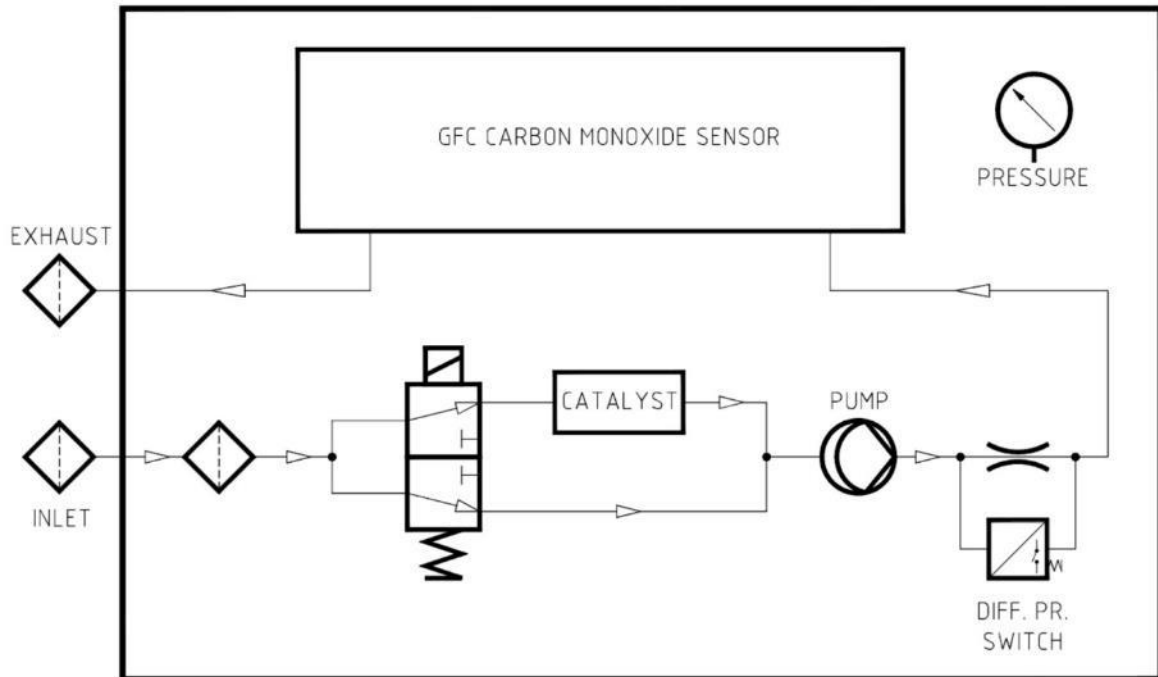


Figure 6 COSAMS internal pneumatic arrangement

6.1 Gas sampling

Sample gas is drawn in to the COSAMS through a push-in pre-filter in the underside of the cabinet and then passes through an internal particulate filter.

After filtering, the sample flows through a solenoid valve which is energised periodically to temporarily divert the sample through an extra loop of pipework. This extension to the gas path incorporates a canister containing a catalyst which removes any CO present in the sample stream, allowing the COSAMS to trim out any baseline signal drift.

The sample pump is downstream of the solenoid valve/catalyst and the output from the pump passes through an orifice restrictor to limit the rate of gas flow through the sensor. A pressure switch monitors the pressure drop across the restrictor and an absence of pressure drop is interpreted as a lack of sample flow. Gas exits the sensor's optical bench and exhausts through the outlet on the right-hand-side of the COSAMS cabinet.

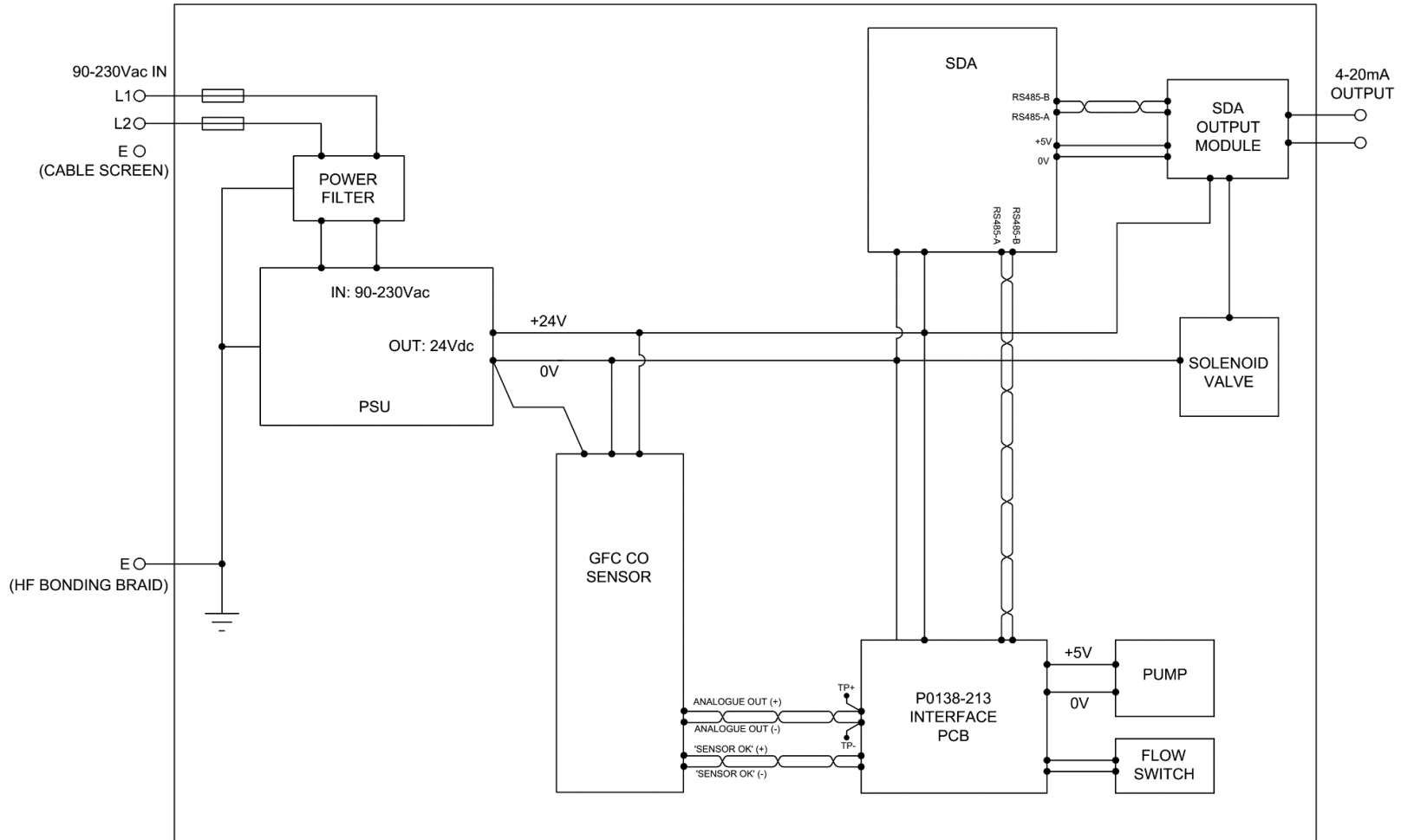


Figure 7 COSAMS internal electrical arrangement (AC variant)

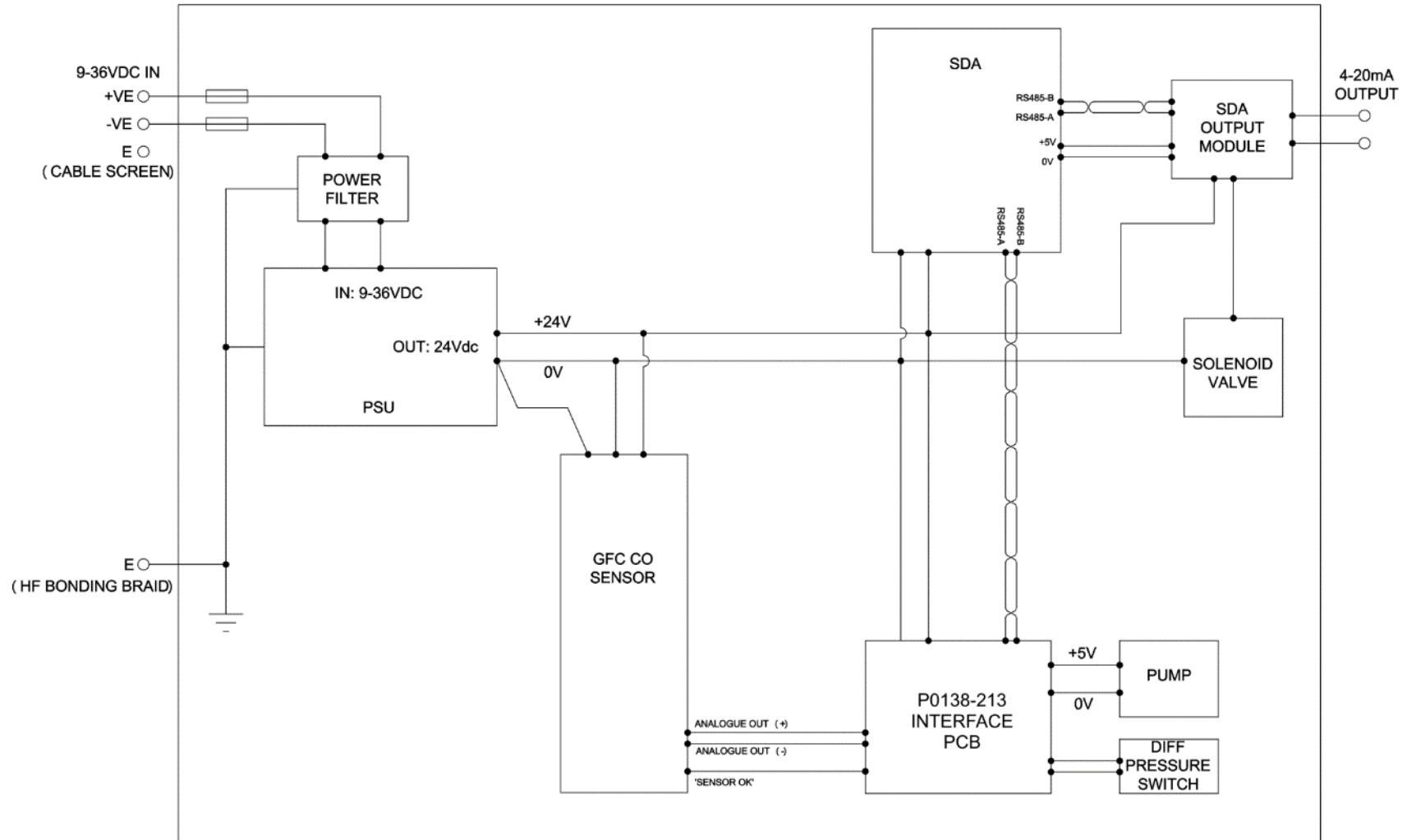


Figure 8 *COSAMS internal electrical arrangement (DC variant)*

6.2 Power supply

The COSAMS can be supplied with either an AC power supply or a DC power supply, this should be stipulated at the time of order.

6.2.1 Power supply (AC variant)

The COSAMS is powered from the boat's 115V, 60Hz AC supply. The screen of the incoming power cable is earthed at the supply end and connected to the shell of the cable connector, providing 360 degree EMC protection.

It is expected that the electrical supply will be floating with respect to the submarine hull, therefore both inputs (*L1* and *L2*) are fused. Fuses *F1* & *F2* are housed in externally-accessed, waterproof fuse holders mounted on the left-hand side of the COSAMS cabinet.

Power filtering is performed by a general purpose EMI filter for improved EMC performance. It should be noted that the filter has a 4.7nF capacitor between each line and ground; this level of capacitance to the submarine hull is permissible under MIL_STD-461F, which imposes a 100nF limit.

The filtered supply then connects to a universal input (85 to 264V AC) isolated power supply unit (PSU) which generates a 24V DC supply to power the instrument. The PSU is rated for 70W continuous output; actual DC power consumption is typically 40W with a 55W maximum. Isolation in excess of 500V AC for 60s is provided from input to output, input to case (earth) and output to case (earth).

6.2.2 Power supply (DC variant)

The COSAMS is powered from the boat's low voltage DC supply. The screen of the incoming power cable is earthed at the supply end and connected to the shell of the cable connector, providing 360 degree EMC protection.

It is expected that the electrical supply will be floating with respect to the submarine hull, therefore both inputs (+*VE* and -*VE*) are fused. Fuses *F1* & *F2* are housed in internally-accessed fuse holders mounted on the left-hand side of the COSAMS cabinet.

Power filtering is performed by a general purpose EMI filter for improved EMC performance.

The filtered supply then connects to a universal input (9 to 36V DC) isolated power supply unit (PSU) which generates a 24V DC supply to power the instrument. The PSU is rated for 150W continuous output; actual DC power consumption is typically 40W with a 55W maximum. Isolation in excess of 500V DC is provided from input to output, input to case (earth) and output to case (earth).

6.3 Power distribution

The internally generated 24V DC supply is distributed to the following items:

- CO sensor
- Interface PCB
- SDA operator console
- Solenoid valve circuit for auto-zero calibration (via SDA output module relay contacts)

6.4 CO sensor

The CO sensor measures CO concentration using the *gas filter correlation* (GFC) technique, making use of the infra-red absorption properties of CO. This technique is particularly well-suited to the submarine application as it yields no response to hydrogen (which produces false-positive readings from electrochemical sensors) and has negligible cross-sensitivity to water vapour (unlike standard non-dispersive infra-red absorption sensors).

The CO sensor sub-assembly is a 24V DC-powered device generating a non-linear DC voltage output related to the concentration of CO in its optical bench. This output voltage is fed in to the interface PCB where signal processing takes place.

CO sensor output is set to a nominal 0.8V in the absence of CO (0ppm) and 2.7V when subjected to 200ppm CO at 20°C, 1000hPa.

The CO sensor also supplies the interface PCB with a 'status' output, indicating whether the sensor is operating normally or if an internal fault has been detected.

6.5 5S3 control interface

The interface PCB measures the temperature and barometric pressure within the COSAMS cabinet and applies appropriate compensations to the CO sensor signal prior to calculating the CO concentration in the sample gas stream and reporting to the SDA operator console via an RS485 link (the 5-way connector plugged in to the SDA's *Sensor* socket).

The interface PCB monitors numerous operating parameters, including gas flow and the CO sensor's *Status* line, and reports any fault conditions to the SDA operator console.

The interface PCB also controls timing of the auto-zero function, directing the SDA operator console to energise the solenoid valve when required, and checks the outcome of the operation for plausibility. Other calibration adjustments are performed as directed by the SDA operator console. All sensor calibration data is stored within the interface PCB .

Power to the COSAMS gas sample pump is supplied by the 5S3's internal 5V rail.

6.6 SDA operator console

The SDA is the operator console, or user interface, for the COSAMS.

The SDA's LCD shows the 5S3-derived CO measurement and indicates the system status by the colour of left-hand corner of the display:

Colour	Status
Green	OK
Yellow	Fault detected
Red	CO alarm threshold exceeded

The SDA operator console powers the SDA Output Module and communicates with it over an RS485 link (the 5-way connector plugged in to the SDA's *Data* socket), driving the analogue output to a value commensurate with the measured CO concentration and system status. The SDA also instructs the SDA Output Module to energise the solenoid valve when the interface PCB indicates that an auto-zero is to be performed.

The SDA provides the operator with access to calibration functions and also to logged data via the USB port on the rear of the console.

6.7 SDA output module

The Output Module is controlled by the SDA operator console which supplies 5V DC power and sets the 4-20mA output signal level (refer to Section 5.3.2 for details on the output signal).

The Output Module's *Normally Open* relay is energised to operate the COSAMS solenoid valve during the auto-zero operation.

6.8 Electrical schematic (AC variant)

The internal wiring of the COSAMS is shown in **Figure 9**

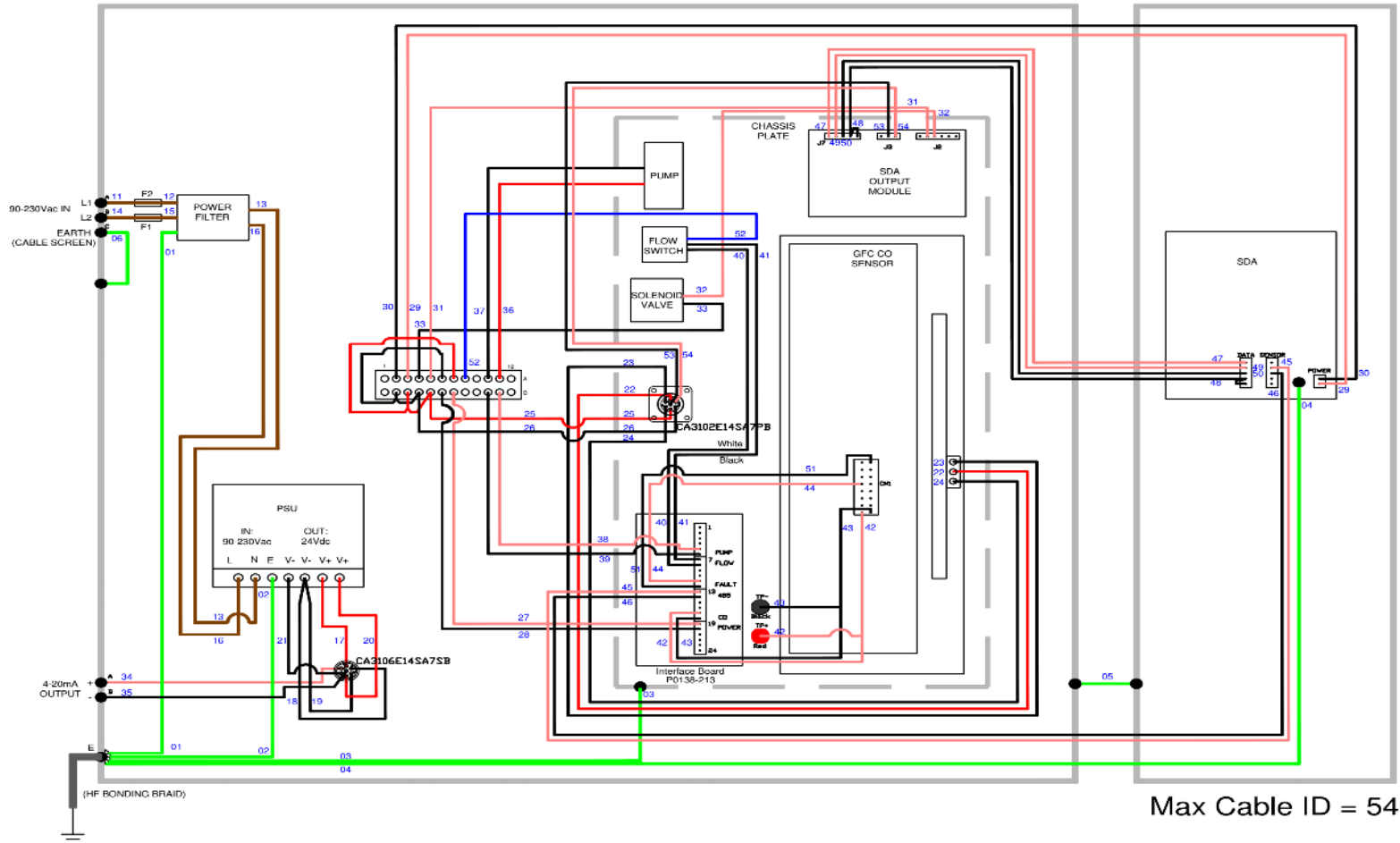


Figure 9 Internal wiring schematic (AC variant)

6.9 Electrical schematic (DC variant)

The internal wiring of the COSAMS is shown in **Figure 10** & **Figure 11**

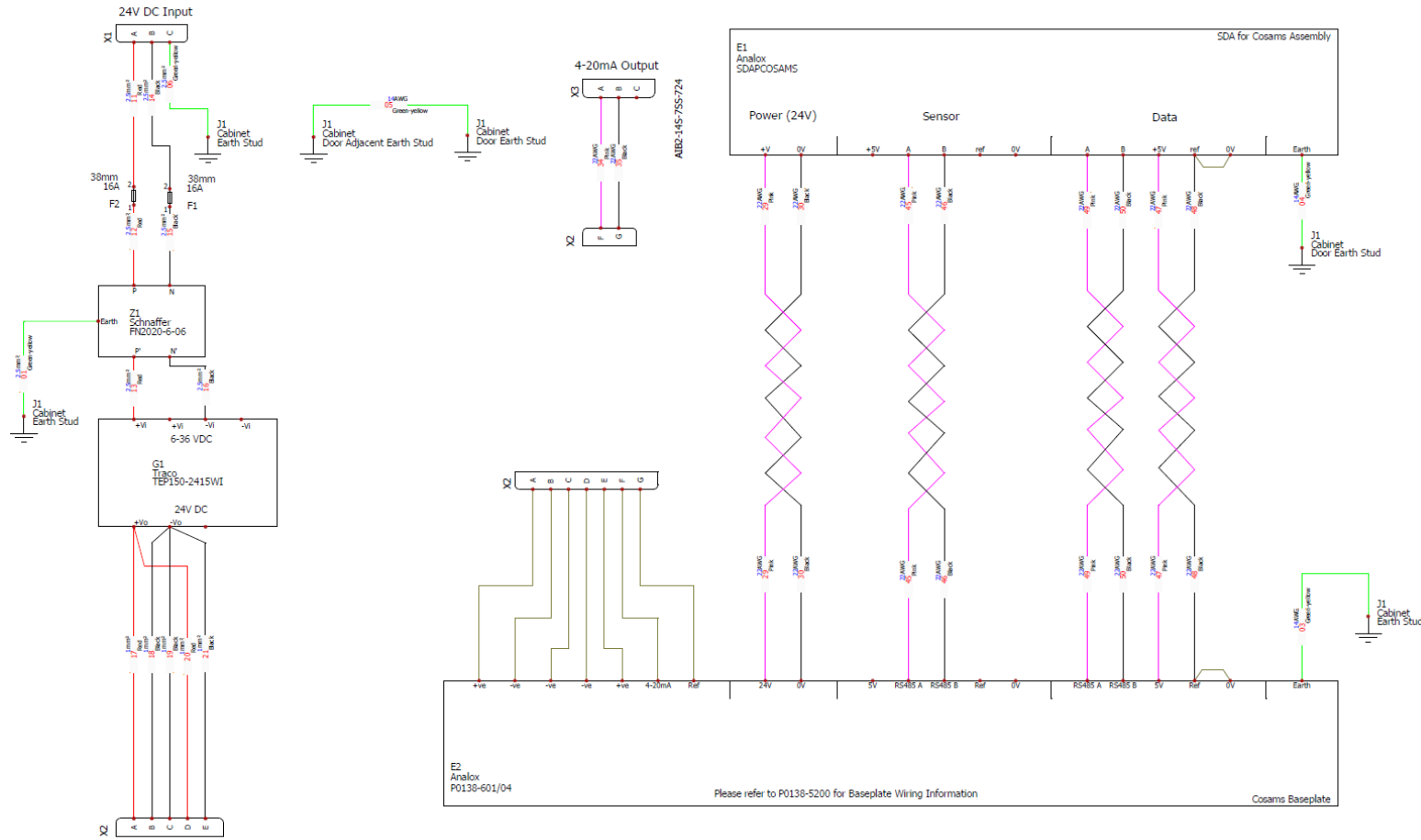


Figure 10 Internal Wiring Schematic (Cabinet) (DC variant)

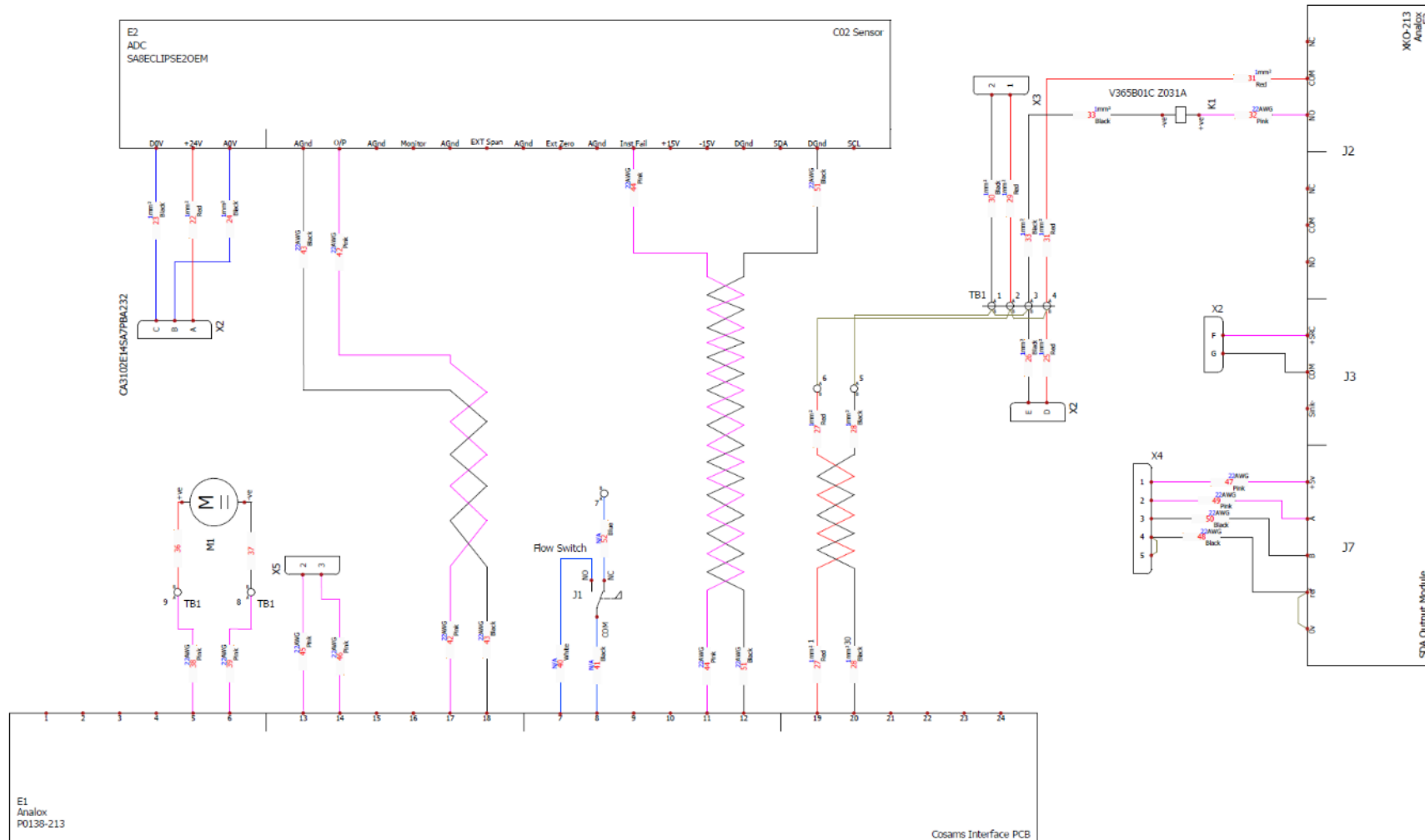


Figure 11 Internal Wiring Schematic (Baseplate) (DC variant)

7 Operating instructions

7.1 Controls

Figure 12 shows the COSAMS front panel:



Figure 12 COSAMS front panel

- 1 LCD
- 2 Rotary encoder
- 3 Mute/Cancel pushbutton
- 4 Menu/Set pushbutton
- 5 Alarm set point controls
- 6 Calibration controls

7.2 Start-up

The COSAMS will automatically start up when power is supplied to it. Initially, the COSAMS will display a splash screen as shown in **Figure 13**, below, for a few seconds:



Figure 13 Start-up splash screen

After displaying the splash screen, the LCD will go blank for approximately 15 seconds and then the 'normal' COSAMS operating screen will display.

7.3 Warm-up

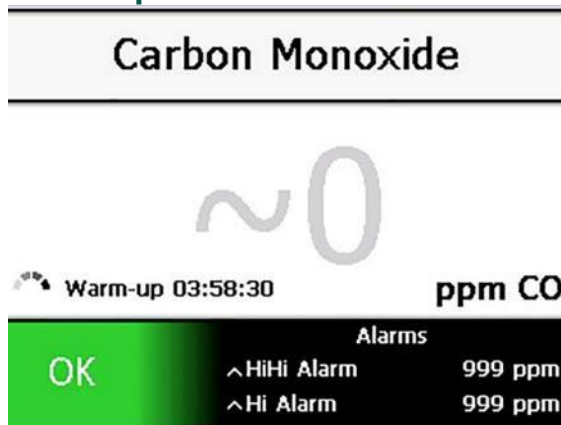


Figure 14 Warm-up screen

Upon start-up, the CO sensor requires a period of up to 4 hours to ‘warm up’ and achieve accurate readings. During this time, the screen will indicate that the sensor is in warm-up mode, displaying a countdown to normal operation, and the CO reading will be shown in grey text preceded by a “~” symbol (see 0), indicating that the value is approximate and should be regarded with a degree of scepticism. The analogue output is clamped to the fault level during warm up. In the event of a brief interruption to the COSAMS power supply, the system will enter a shortened warm-up period with duration being proportional to the time spent un-powered.

7.4 Normal operation

When the warm-up period has expired, the sensor reading will be shown in black text and the analogue output signal will reflect the measured concentration of CO.

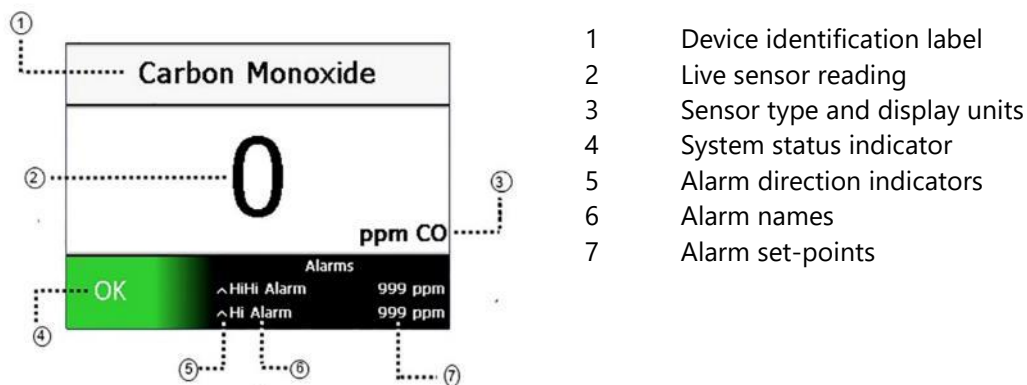


Figure 15 Main display overview

The live sensor reading is updated on the display approximately once per second. If no valid sensor reading is currently available then the last ‘good’ sensor reading will be displayed in grey text preceded by ‘~’.

7.4.1 System status indicator

The system status indicator shows the current status of the COSAMS system. In normal operation, i.e. the absence of any alarm or fault conditions, the system status indicator will be green and read ‘OK’. If any alarm condition has been identified then the system status indicator will turn red and display the word ‘Alarm’.

If a system fault is detected then the status indicator will turn yellow and display the word 'Fault'.
The system indicator also uses icons to show system diagnostic information:



Fault. This icon indicates that a fault has been identified within the system. This icon will be accompanied by a status code. See troubleshooting section for further information on the specific condition. This icon will flash when a new fault condition is identified and until the fault is acknowledged by pressing the mute button.



Processing. This animated icon indicates that the sensor module is performing some internal function, such as calibration.

7.5 Menu

The main menu can be accessed from the main screen by pressing the Menu pushbutton:

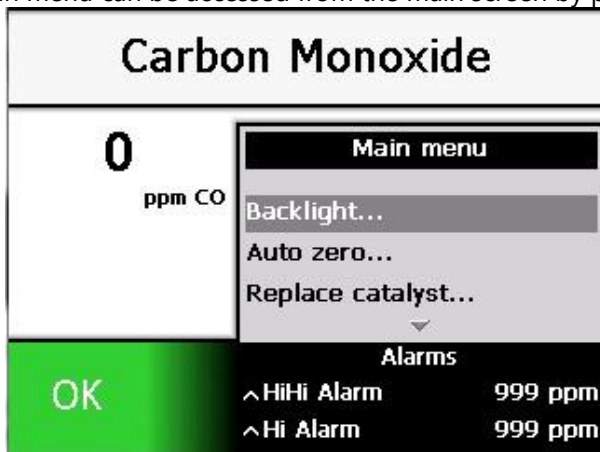


Figure 16 The main menu

An arrow at the top or bottom of a menu indicates that there are more menu options above or below those currently shown.

To select a menu item, rotate the encoder to highlight the required option and press 'Set' to select the highlighted item.

Selecting certain menu items will result in a sub-menu being displayed. Selecting the back option from a sub-menu will return to the previous menu level.

The 'Cancel' pushbutton can be pressed at any time whilst using the menu to exit from the menu.

The menu options available are listed in **Table 8**

Menu item	Purpose
Backlight...	Control the intensity of the display backlight
Auto-zero...	Instruct the COSAMS to perform an auto-zero calibration
Replace catalyst...	Instruct COSAMS that a new catalyst module has been fitted
Service...	Instruct the COSAMS that a service has been completed
Information	Access system information
Data logging	Access options to manage data log information
Exit	Exit from menu and return to normal operating screen

Table 8 SDA operator console menu items

7.5.1 Adjusting the backlight

The brightness of the COSAMS display can be changed to suit the local lighting conditions by adjusting the backlight intensity.

Selecting the 'Backlight' option from the main menu results in the 'Set backlight' sub-menu being displayed. Highlight the desired backlight intensity level (10 to 100%) and press the *Menu/Set* pushbutton.

To exit from the sub-menu without changing the backlight intensity, either press the *Mute/Cancel* pushbutton or select the 'Back' option to return to the main menu.

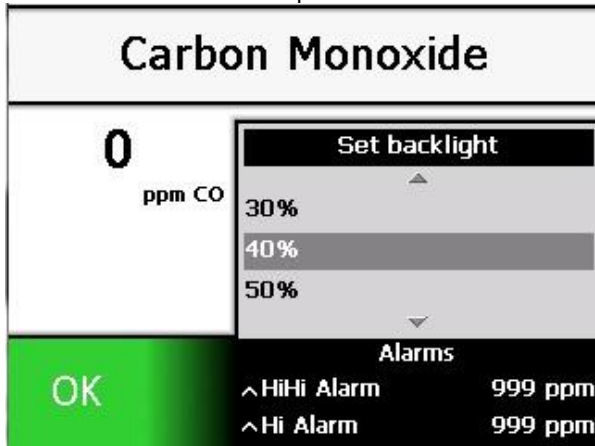


Figure 17 The backlight sub-menu

- ◆ **CAUTION:** DUE TO THE NATURE OF THE DISPLAY TECHNOLOGY, THE MAXIMUM INTENSITY OF THE DISPLAY WILL DEGRADE SLIGHTLY OVER THE LIFESPAN OF THE PRODUCT. FOR NEW SYSTEMS IT IS RECOMMENDED THAT THE BACKLIGHT IS SET TO AN INITIAL INTENSITY LEVEL OF 60% OR LESS TO MAXIMISE THE LIFESPAN OF THE DISPLAY.

7.5.2 Auto-zero function

The auto-zero function is initiated automatically after the COSAMS warm-up period has expired and then periodically thereafter to trim out any drift in the sensor’s baseline output. The user may also manually initiate an auto-zero operation via the menu option, allowing a zero calibration to be performed when a technician does not have access to zero calibration gas.

During the auto-zero process, the solenoid valve is energised to divert flow through the catalyst module, scrubbing the gas of any CO by oxidising to CO₂. The COSAMS will not monitor ambient CO concentration whilst engaged in the auto-zero so the CO reading will be displayed in grey and preceded by the '~' symbol; the 4-20mA signal level will be maintained at the same level as immediately prior to starting the auto-zero.

Factory default timings for the auto-zero operation are:

- Period between auto-zeroes: 6 hours
- Auto-zero duration: 3 minutes

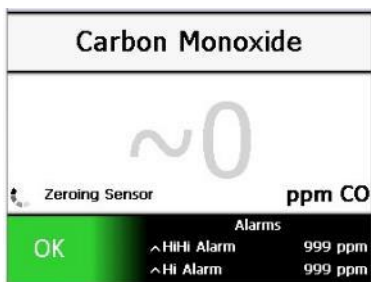


Figure 18 Zeroing sensor indication

7.5.3 Replacing catalyst

If the COSAMS rejects an auto-zero result due to a suspected problem with the catalyst, the ensuing fault announcement (see **Table 9**) can be cleared by selecting the *Replace catalyst...* option.

7.5.4 Resetting the service interval timer

After servicing the COSAMS, the service interval timer may be reset to 1 year by selecting the *Service...* option.

7.5.5 COSAMS information

An information screen can be accessed to check the configuration of the system. From the Main Menu, select the 'Information' option.



Figure 19 COSAMS information screen

This screen shows the software version number, the instrument serial number, various settings, and the time until a service is due.

7.5.6 Data logging

The SDA unit logs measurement data over a 90-day period at 10-second intervals. The following parameters are logged:

1. System status
2. Average CO reading over the last 10s period
3. Minimum CO reading during the last 10s period
4. Maximum CO reading during the last 10s period

When the log is full, i.e. 90 days of data has been collected, the oldest data is over-written such that the log contains a continuous record of the preceding 90 days.

7.5.6.1 Downloading logged data

Logged data is available to the user via the USB port located on the rear of the SDA. The data provides the following information:

08/01/2014	12:44:16	OK	ppm	0	0	0
08/01/2014	12:44:26	OK	ppm	0	0	0

Figure 20 Example of data logged by system

To download logged data:

- [1] Plug a USB flash drive into the USB port on the SDA (this is on the rear of the enclosure door - see the photograph below):**



- 1] Go to the SDA operator console on the front of the enclosure door.
- 2] Press the Menu/Set button, then scroll through the options using the rotary encoder.
- 3] Press the Menu/Set button again to select the 'Data logging' Menu option.
- 4] Press the Menu/Set button again to select 'Download data to USB...' Data will download to the USB flash drive, with one CSV file for each day of data. When download is complete, the files can be imported directly to Microsoft Excel or similar spreadsheet packages.

To delete logged data:

- 1] Press the Menu/Set button, then scroll through the options using the rotary encoder.
- 2] Press the Menu/Set button again to select the 'Data logging' Menu option.
- 3] Press the Menu/Set button again to select 'Delete all data-logs'. All logged data will be deleted.

To download logged data using the Data Download Tool (DDT) (Analox branded USB stick):

- 1] **When using the Data Download Tool the files stored on the COSAMS device will not be affected.**
- 2] **Open the COSAMS enclosure using the supplied cabinet key**



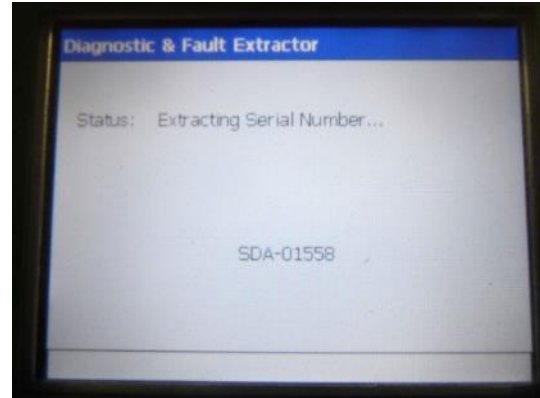
- 3] **Locate the USB "TECH" port on the rear of the SDA Operator Console (SOC) and fit the DDT**



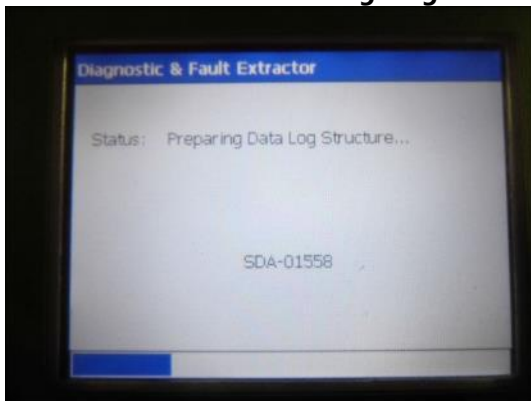
- 4] **Locate and unplug the power supply cable in the back of the SOC designated by idents 30 (black wire) and 29 (red wire). After a minimum period of 5 seconds reconnect the power supply cable in the back of the SOC.**



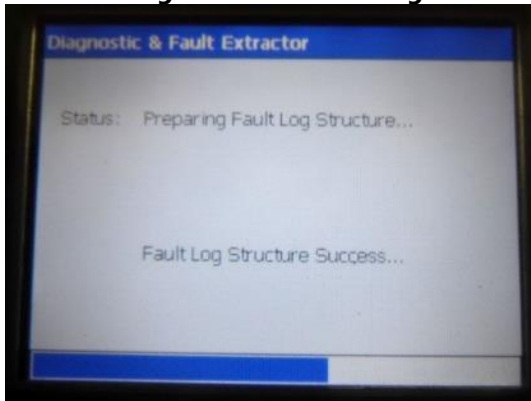
- 5] **Check the SOC display shows the device splash screen. After a short period the splash screen will go blank before the DDT Diagnostic & Fault Extractor software starts.**



6] This will automatically download the device datalogs, Once datalog download is complete the device will start downloading diagnosis logs



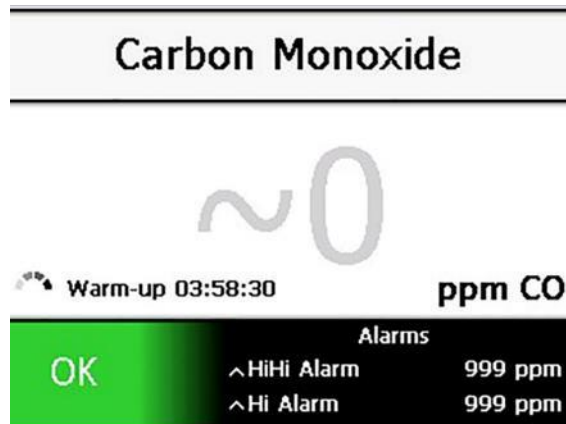
7] Once datalogs finish the fault log download will start.



- 8] Once all downloading is complete the Status will show as finished and request the USB device to be removed.




- 9] Once the USB device is removed, close the COSAMS cabinet door and lock.



- 10] The SOC will automatically reboot and enter a reduced COSAMS warm up period prior to normal operation mode.

8 Calibration


-  **CAUTION:** **INCORRECT USE OF CALIBRATION GAS CAN ADVERSELY AFFECT THE INSTRUMENT'S PERFORMANCE. ONLY TRAINED PERSONNEL SHOULD ATTEMPT CALIBRATION.**

It is intended that the COSAMS be calibrated immediately prior to a sortie or every 30 days to maintain accuracy. The auto-zero function, described in section 7.5.2, maintains accuracy during the period of the patrol.

8.1 Zero and span calibration

Two gases are required to calibrate the COSAMS, *zero* gas (0ppm CO) and *span* gas (a high concentration of CO in air balance), as detailed in section 12.2.

Zero gas calibration should be performed first, followed by *span* gas calibration.

-  **NOTE:** **THE COSAMS MONITORS THE AMBIENT AIR AT THE GAS INLET TO THE INSTRUMENT, USING AN INTERNAL PUMP TO DRAW A GAS SAMPLE THROUGH THE SENSOR.**

Calibration gas may be connected to the sample inlet while calibrating, provided it is controlled by a suitable regulator as described in section 8 and section 12.4.8.

Gas pressure at the inlet port must not exceed 500hPa (gauge pressure).

Do not obstruct the exhaust port.

8.1.1 Performing a zero calibration

- 1] Remove the push-fit pre-filter in the gas inlet and supply the COSAMS with zero gas at a flow rate of 0.5 – 0.7 lpm via Ø6mm tubing.
- 2] Maintain the gas flow for approximately 3 minutes, by which time the COSAMS CO reading should have reached a steady value.
- 3] Press and hold the *Zero Calibrate* pushbutton and press the *Menu/Set* pushbutton to initiate the calibration. Releasing the *Zero* pushbutton before pressing *Menu/Set* will abort the calibration and return the COSAMS to normal operation.
- 4] The COSAMS will attempt a calibration, resulting in either a 'Calibration OK' or a 'Calibration failed' message as shown in 0
- 5] Press the *Mute/Cancel* button to clear any calibration messages that may remain on-screen.

8.1.2 Performing a *span* calibration

- 1] Switch from *zero* gas flow to *span* gas flow and maintain 0.5 – 0.7 lpm flow rate for approximately 3 minutes, by which time the sensor reading should have reached a steady value.
- 2] Press and hold the *Span Calibrate* pushbutton; the calibration value entry panel will be shown (0) with the cal. gas CO concentration displayed in blue.
- 3] Use the rotary encoder to adjust the value to the CO concentration in the calibration gas.
- 4] Press the *Menu/Set* pushbutton to initiate the calibration. Releasing the *Span* pushbutton before pressing *Menu/Set* will abort the calibration and return the COSAMS to normal operation.
- 5] The COSAMS will attempt a calibration, resulting in either a 'Calibration OK' or a 'Calibration failed' message as shown in 0 below.
- 6] Press the Mute/Cancel button to clear any calibration messages that may remain on-screen.

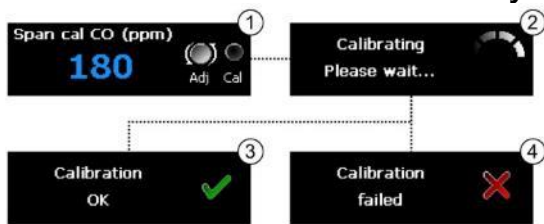


Figure 21 *Span adjustment*

9 Alarms

The COSAMS can provide two alarm indications, triggered on detection of a high level (*Hi*) of CO and very high level (*Hi Hi*). COSAMS is supplied with these alarm thresholds set at 999ppm CO, effectively disabling alarm annunciation. It is possible to bring the alarms in to use by adjusting the alarm set points to within the COSAMS' range of measurement, as described in section 9.1.

Alarm annunciation is limited to visual indication on the SDA operator console: the system status indicator will flash red and display 'Alarm', the measured CO concentration will be displayed in red text and the relevant alarm set point will display in red text. Audible alarm annunciation is inhibited.

The 4-20mA output signal is completely unaffected by alarm state.

9.1 Adjusting alarm set points

If desired, the user may adjust the set point(s) to within the CO measurement range, thereby activating the alarm(s).

NOTE: IF THE SDA OPERATOR CONSOLE IS USED TO ACTIVATE THE ALARMS IN THE MANNER DESCRIBED BELOW THEN THE TECHNICAL IN-SERVICE SUPPORT SOFTWARE DESCRIBED IN SECTION 33 WILL BE REQUIRED TO RETURN THE SET POINTS.OUT-OF-RANGE; THE MAXIMUM SET POINT VALUE ACHIEVABLE VIA THE OPERATOR CONSOLE IS 200PPM CO.

To adjust a set-point, press and hold the relevant alarm-adjust pushbutton - top button for *Hi Hi* alarm, bottom button for *Hi* alarm. The alarm adjustment panel will be shown at the bottom of the LCD, alongside the system status indicator. The panel shows the name of the alarm to be adjusted and the current alarm set-point in yellow (**Figure 22**).

Keep the alarm-adjust pushbutton depressed and use the rotary encoder to adjust the set-point: turn clockwise to increase, anti-clockwise to decrease.

NOTE: TO QUICKLY REDUCE THE ALARM SETTING FROM THE INITIAL 999PPM SETTING, SIMPLY ATTEMPT TO ADJUST THE SETPOINT UPWARDS (CLOCKWISE). THE VALUE WILL THEN SNAP TO 200PPM, FROM WHERE IT CAN THEN BE ADJUSTED NORMALLY.

When the desired set value is reached, keep the alarm-adjust pushbutton depressed and press the *Menu/Set* pushbutton to accept it; the value will turn green, indicating confirmation of the new set point and the alarm-adjust push button can be released.



Figure 22 Example of alarm set-point adjustment

NOTE: RELEASING THE ALARM-ADJUST PUSHBUTTON PRIOR TO CONFIRMATION WILL RETURN THE SET POINT TO ITS ORIGINAL VALUE.

9.2 Acknowledging alarms

COSAMS alarms are latching meaning that, once triggered, the alarm annunciation will continue until acknowledged by an operator, even if the CO concentration returns to a low level.

Alarms are acknowledged by pressing the *Mute / Cancel* pushbutton.

If the alarm condition no longer exists when the alarm is acknowledged then the LCD will revert to its normal operating condition upon acknowledgement, otherwise, the system status indicator will remain red but cease to flash, the CO will still be displayed in red, as will the appropriate alarm set point. Only when the alarm condition has cleared will the display revert to normal operation.

9.3 Clearing alarms and hysteresis

An alarm will always trigger immediately when the sensor reading exceeds an alarm set point. However, to avoid nuisance re-triggering of alarms when a sensor reading is fluctuating around an alarm set point, the CO level must drop a certain amount below the set point before an acknowledged alarm will clear. This difference between the alarm set point and the lower CO level at which an acknowledged alarm will clear is the alarm's hysteresis.

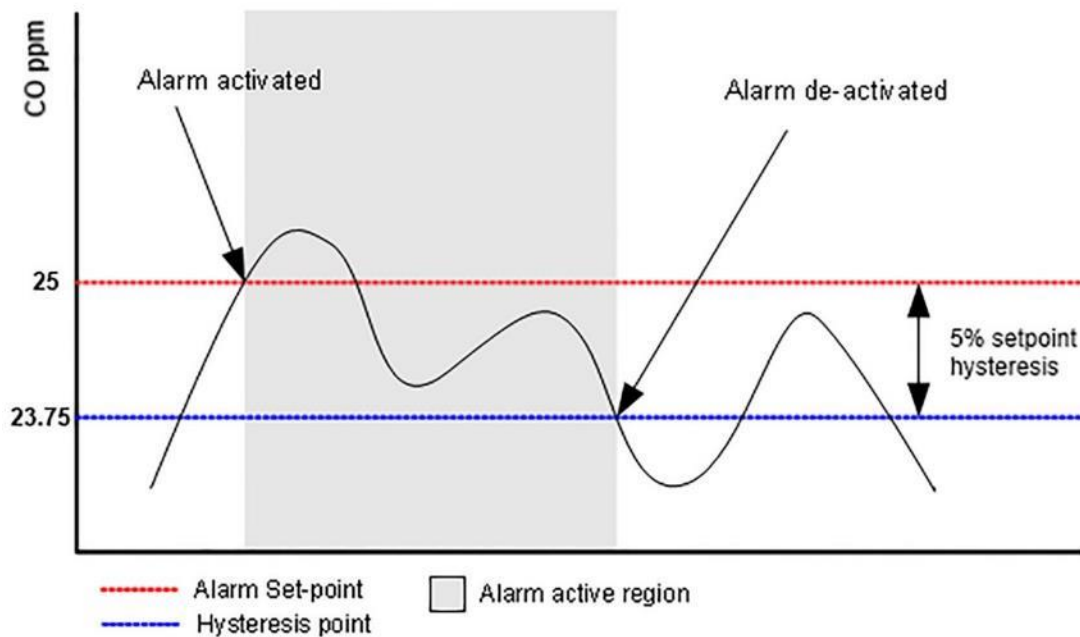


Figure 23 Alarm hysteresis

The hysteresis applied to an alarm is calculated as a percentage of the set point value with an upper limit imposed.

10 Technical in-service support software

COSAMS SDA software is provided to allow the device to be configured using a USB connection. The software is designed to run on Microsoft Windows®. Please refer to the COSAMS Software Manual P0138-812 contained on the COSAMS Software CD.

The utilities on the CD are not required in normal use but may be of benefit in the event of in-service support being required.

11 Troubleshooting

11.1 Fault announcement

The COSAMS constantly monitors for fault conditions; any that are identified will trigger a fault announcement.

The system status indicator will flash yellow, and the 4-20mA signal will be set to ~2mA.

Fault announcements can be acknowledged by pressing the *Mute/Cancel* button; the system status indicator will cease to flash and analogue output will remain high until the fault condition is rectified.

All fault announcements are latching; if an intermittent fault condition is identified and subsequently clears (e.g. gas flow is temporarily interrupted), the fault announcement will continue until it has been acknowledged.

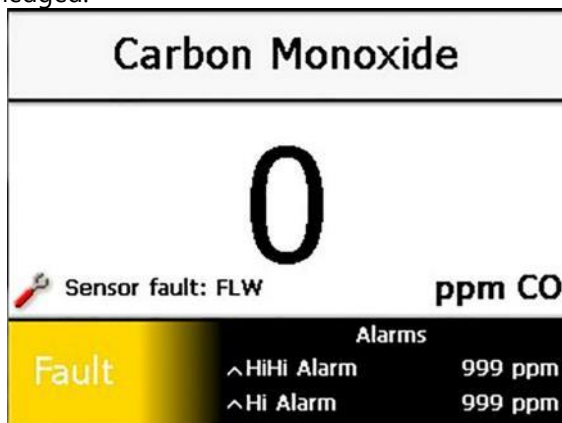


Figure 24 Fault indication (example of a flow fault)

11.2 Fault diagnosis

Information about the fault condition is displayed just below and to the left of the CO reading, as shown in **Figure 24**.

In cases where a fault prevents a valid reading from being obtained from the sensor, then the last good reading will be shown in grey, preceded by '~'.

11.3 Fault logging

All instances of fault conditions that are identified will be logged to the COSAMS's diagnostics log (both the point at which the fault is identified and the point at which the fault is cleared will be logged).

The diagnostics log can be downloaded using the COSAMS SDA software.

Please refer to the COSAMS Software Manual P0138-812 contained on the COSAMS Software CD for information on how to access this.

Table 9 shows a full list of fault messages together with a description of the cause and suggested remedies.

Fault message	Cause	Solution
Sensor fault: OMF	Unable to establish communications between SDA and Output Module via RS485 communication link.	Check integrity of comms connections on SDA and Output Module. If connections are satisfactory but fault persists, replacing the Output Module or the SDA Operator Console may solve the problem.
Sensor fault: ACZ	The auto-zero calibration process did not complete successfully: - the sensor output has drifted too far from its initial value or - another fault condition, which might prevent correct calibration, was detected during the procedure	Check calibration of sensor using zero gas (section 12.4.8). If catalyst is OK, then this should also result in a calibration fault. If catalyst is the problem, then calibrate with zero gas should succeed. To identify whether or not the catalyst is the source of the problem, first ensure that the switching solenoid is operating. The solenoid valve is switched by a relay in the Output Module, so ensure that power is reaching the solenoid valve via the Output Module relay. If all OK, but auto-zero still fails, then replace catalyst module.
Sensor fault: CAT	The auto-zero calibration did not complete successfully, the calculated adjustment required has changed by an unacceptable amount since the previous auto-zero.	Check operation of the solenoid valve. If the valve is switching satisfactorily, replace the catalyst module. Reset the catalyst fault from the main menu as detailed in section 12.3.2.
Sensor fault: CRC	Code or data corruption within interface PCB.	Should the interface PCB need to be replaced, contact Analox.
Sensor fault: FLW	Defective flow switch or insufficient gas flow caused by any of: - Blocked inlet filter - Blocked outlet filter - Blocked internal filter - Defective pump - No electrical supply to pump - Internal pipework leak	Check pump is running – if it isn't, check that 5V DC supply from interface PCB is good. Check inlet, outlet pre-filters and internal filter for line blockage. Check pipework connections are good. Check flow switch operation.
Sensor Fault: ICF	The 5S3 control interface has detected a low level on its 'GFC OK' signal line.	Check integrity of the 'GFC OK' signal wiring. If connection between the GFC sensor and 5S3 control interface PCB is good then contact Analox.
Sensor comms fault	Communications between SDA and interface PCB have been interrupted/lost.	Check integrity of comms connections on SDA and interface PCB.. If connections are satisfactory but fault persists then contact Analox.
Sensor fatal error	Interface has experienced a fatal error.	Should the interface PCB need to be replaced, contact Analox.

Fault message	Cause	Solution
Sensor fault: NFF	An unexpected non-fatal fault has occurred.	Note the occurrence of the alarm and report to Analox together with any information which may be relevant. Acknowledge the fault and attempt to continue operating.
Sensor Fault: PWR	The interface PCB's internally generated 5V DC is out of specification.	Condition may be caused by faulty pump which is powered by the interface PCB's 5V DC rail. If pump is OK the interface PCB may need replacing; contact Analox.
Sensor range fault	The CO reading is below the expected minimum value.	Recalibrate using SDA operator console. If fault persists, perform a 'coarse' calibration, as described in section 12.4.8. If this cannot be achieved, contact Analox.
Sensor range fault: NFF	The interface PCB has reported a pressure reading falling outside the expected range.	If the pressure is considered within the normal range, then contact Analox.
Sensor fault: TMP	Unit is operating outside the operating temperature range.	Check ambient temperature – if within the COSAMS operating range then contact Analox.
Pressure: PRE	Pressure is outside the range of the unit.	Note the occurrence of the alarm and report to Analox together with any information which may be relevant. Acknowledge the fault and attempt to continue operating.
Initialisation: INT	System has not initialised correctly	Note the occurrence of the alarm and report to Analox together with any information which may be relevant. Acknowledge the fault and attempt to continue operating.
Noise: NSY	Outside of power supply unit's operating range.	Check the power supply unit (PSU). Note the occurrence of the alarm and report to Analox together with any information which may be relevant. Acknowledge the fault and attempt to continue operating.
CRC error: CRC	Flash memory is corrupt.	Note the occurrence of the alarm and report to Analox together with any information which may be relevant. Acknowledge the fault and attempt to continue operating.

Table 9 *Fault codes*

12 Maintenance

12.1 Spare parts

Table 10 shows spare parts available to order:

Item	Description	Analox part number
1.	Power input connector (To be ordered with item 3)	2535-0114
2.	Signal output connector (To be ordered with item 3)	2535-0115
3.	Heatshrink boot	2535-0116
4.	Carbon Monoxide Detector (COSAMS) Locking Key (Triangular)	E3-3-1
5.	USB lead	9300-1008
6.	COSAMS software CD	P0138-907
7.	COSAMS User Manual	Dependant on version
8.	Case breather	9456-1538
9.	Power filter	Dependant on version
10.	Fuse holder	Dependant on version
11.	Fuse	Dependant on version
12.	Power supply	Dependant on version
13.	Sample Pump Kit (Includes Pump & Mounting Hardware)	DD1COSAMSPK-MOD03
14.	Solenoid valve	6000-0194
15.	Flow Sensor (Inc. Mounting Bracket & Push Fit Elbows)	FS6202CV-1M-COSAMS
16.	Analox COSAMS SDA operator console	Dependant on version
17.	SDA Output Module PCB	XK0-213-COSAMS-00
18.	Gas inlet/outlet pre-filter	6000-0193
19.	Catalyst assembly (internal)	P0138-603
20.	Replacement internal filter element and O-ring (Pack of 10)	2533-1100
21.	Infra-red source for GFC CO sensor	5000-0254-0021
22.	Door EMC Gasket (Supplied in 1 metre lengths)	2321-0117
23.	COSAMS membrane switch label	P0138-407
24.	Baseplate assembly including sensor	Dependant on version

Item	Description	Analox part number
25.	COSAMS Data Download Tool (DDT)	COSAMS DDT
26.	Potentiometer Adjustment Tool	0000-0181
27.	Replacement internal filter element, 5um (Pack of 10)	2533-1100
28.	Air Suction Filter, 100 Series, 6mm Push, Filtration 5um	2533-1009

Table 10 COSAMS spare parts list

Sundry minor fasteners and pneumatic items can also be supplied, if required. Please contact Analox for further information.

12.2 Special maintenance equipment

Besides common hand tools (screwdrivers, spanners, multi-meter, etc.), Analox recommend that the following equipment is available for maintaining the system and ensuring optimal performance:

Item	Description
1	Analox COSAMS software CD (supplied with system)
2	USB cable (supplied with system)
3	PC or laptop running Windows XP or later for use with Analox software (not supplied by Analox)
4	Zero calibration gas: 20.9% oxygen in nitrogen recommended (to be sourced locally)
5	Span calibration gas: 150ppm CO in air recommended (to be sourced locally)
6	Demand flow regulator required for calibration gas bottles; required flow rate is approximately 0.6 lpm
7	Calibration gas hose (COSAMS gas inlet accepts 6mm outside diameter)

Table 11 Special maintenance equipment

Choice of calibration gas bottle will be subject to preference, being a compromise between storage space requirements, portability and capacity/longevity.

Analox recommend that a fairly small bottle is chosen, allowing the gas to be carried on board the submarine. For example, in the UK we would recommend the use of 110 litre S-Can bottles (360mm long x Ø86mm, 1.55 litres water capacity, fill pressure of 68 bar).

A demand flow regulator, suitable for use with instruments that use a pump to draw a sample should be used to deliver gas to the COSAMS. Flow rate will be in the region of 0.6 lpm.

150ppm CO in air is recommended for performing span calibration; this concentration has been chosen to match that used for calibrating previous CO sensors. Any CO concentration in the range 120 – 200ppm CO could be used, if required.

12.3 Periodic maintenance

NOTE: A RECOMMENDED SPARES AND MAINTENANCE INTERVALS GUIDE WILL BE INCLUDED WITH THE PRODUCT (DOCUMENT NUMBER P0138-918). THIS INCLUDES RECOMMENDED MAINTENANCE INTERVALS AND REPLACEMENT PART NUMBERS. WE RECOMMEND THIS DOCUMENT IS USED TO TRACK ANY MAINTENANCE CARRIED OUT ON THE COSAMS.

The Analox COSAMS has been designed to require minimal maintenance and minimal spare parts inventory. Most elements of the system maintenance can be carried out by Level 1 (on board maintenance personnel). Level 3 (contractor maintenance) should only be required during either safety control maintenance or main overhaul.

The following have been identified as on-board maintenance tasks that are required to ensure optimal operation, all tasks can be performed by submarine technical personnel:

Item	Task	Frequency
1	Check condition of inlet & outlet pre-filters and internal filter. Replace as necessary (12.3.1)	Initially per mission, but expected to be relaxed to every 6 months
2	Sensor calibration	Pre-deployment or 6 monthly
3	Replacement of sample pump (12.3.5)	12 months
4	Replacement of auto-zero catalyst module (12.3.2)	3 months
5	Check condition of cabinet breather port and replace if necessary (12.3.3)	2 years
6	Replacement of GFC sensor's infra-red source (12.3.6)	2 years
7	Replacement of SDA operator module (12.4.7)	7 years
8	Replacement of base plate assembly (12.3.4)	7 years

Table 12 On board maintenance tasks

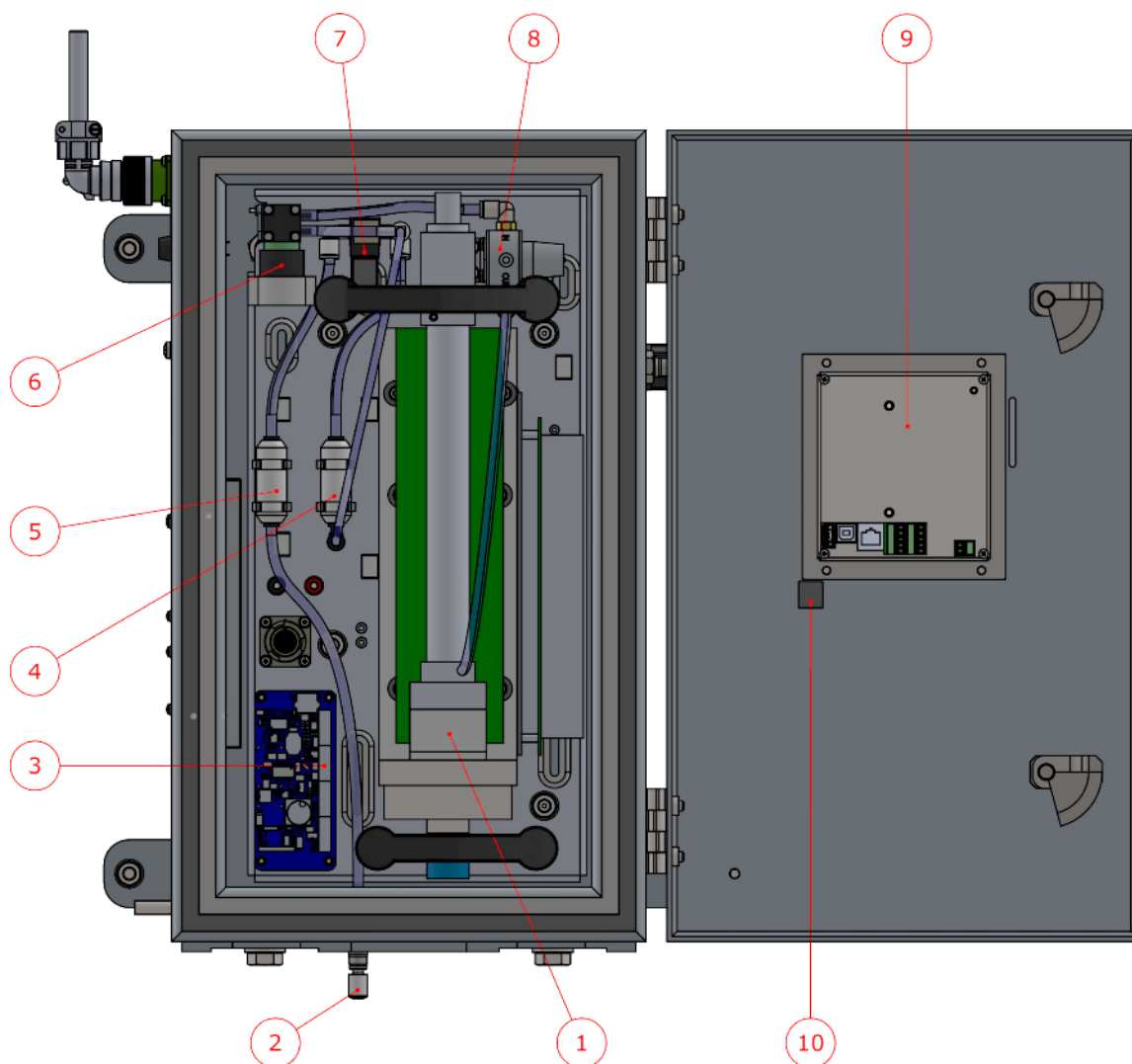


Figure 25 COSAMS internal components (1)

Key

- | | | | |
|---|-----------------------------|----|----------------------|
| 1 | GFC CO sensor | 6 | Sample Pump |
| 2 | Inlet pre-filter | 7 | Solenoid valve |
| 3 | COSAMS interface PCB | 8 | Flow switch |
| 4 | Auto-zero catalyst module | 9 | SDA operator console |
| 5 | Internal particulate filter | 10 | Rotary encoder |

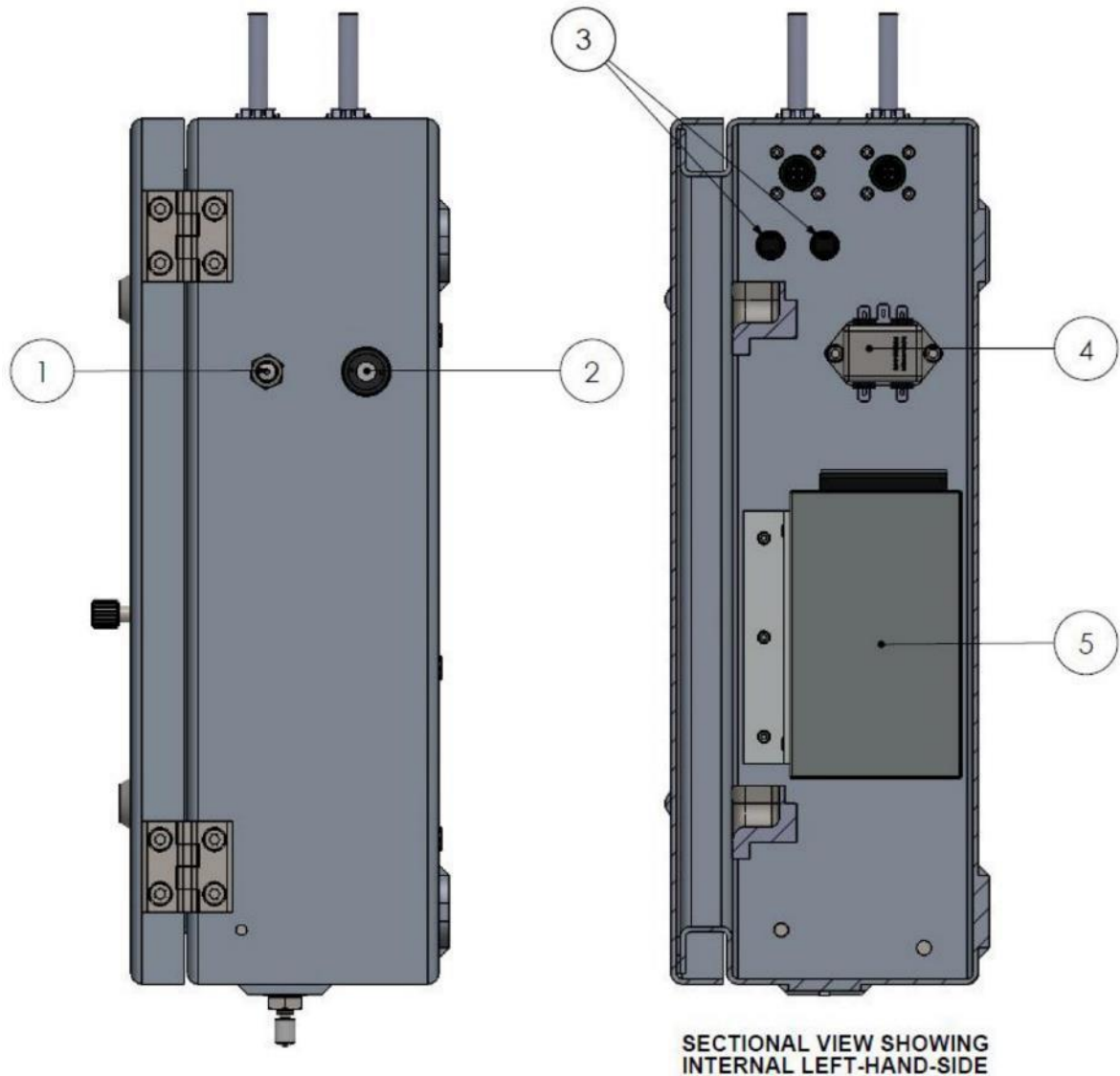


Figure 26 COSAMS internal components (2)

Key

- 1 Exhaust pre-filter
- 2 Breather port
- 3 Fuse holders (AC variant), fuse holders are located internally on DC variants
- 4 Power filter
- 5 Power supply unit (PSU)

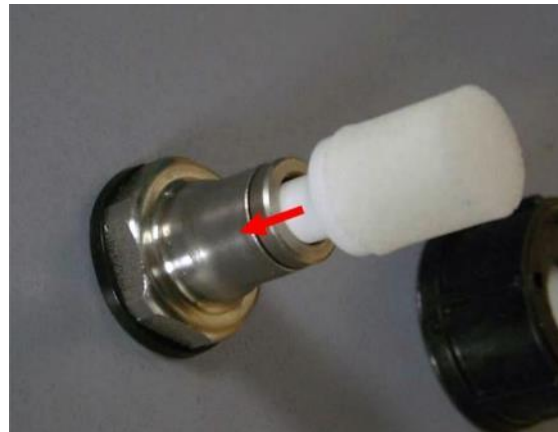
⚠ WARNING: DISCONNECT THE POWER SUPPLY BEFORE PERFORMING ANY MAINTENANCE WITHIN THE CABINET.

12.3.1 Filter check and replacement

There are 3 filters requiring periodic replacement: the inlet and outlet pre-filters, which are identical and the internal particulate filter.

12.3.1.1 Gas inlet and exhaust pre-filters

The pre-filters are push-fit fittings – remove by pushing the fitting's collar against the body of the fitting and withdrawing the pre-filter.



12.3.1.2 Internal filter element replacement

The internal filter is a cartridge-type, mounted on the baseplate assembly within the COSAMS unit.

- 1] **Unclip the left most cartridge from its bracket by pulling it away from the baseplate.**
- 2] **Remove the tubing from the inlet (bottom) and tubing from the outlet (top) by pushing the collar of the fitting toward the body of the cartridge to release the grip on the elbow/tube.**
- 3] **Open the cartridge and remove the filter element by rotating the inlet end of the cartridge anticlockwise to the open ('O') position.**





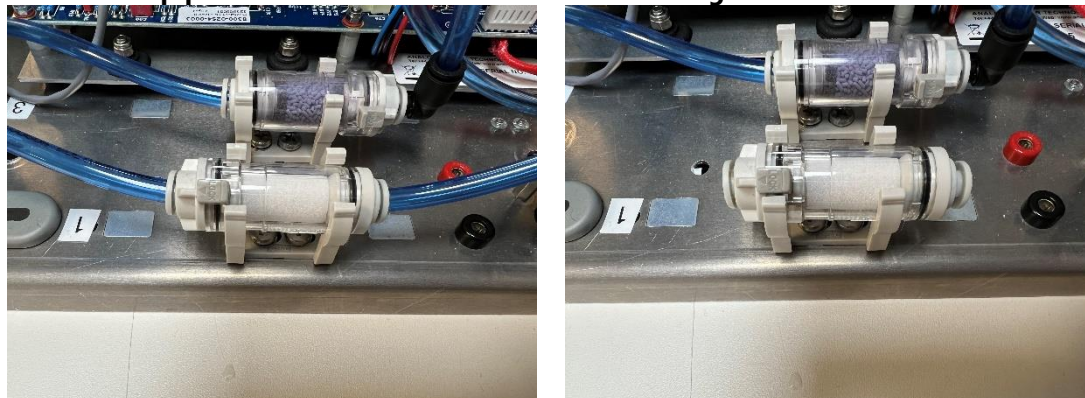
- 4] Pull out the inlet fitting and remove the filter element.
- 5] Inspect the O-ring on the inlet fitting and if damaged in anyway, or showing signs of wear, the full filter housing including a new element is required to be replaced (See section 12.3.1.3).
- 6] Insert the new filter element, re-assemble the cartridge and re-install in the COSAMS.

12.3.1.3 Replacing the filter housing (Inc. element)

The complete filter housing is supplied with a mounting bracket, the mounting bracket can be disposed of as this is already fitted to the baseplate.

If the oring is found to be damaged or showing signs of wear during the filter element change, the full filter housing inc. the element is required to be replaced.

- 1] Remove the pipework from each end of the filter housing.



- 2] Pull the housing from its bracket.



- 3] Reverse previous steps to install the new filter housing, observing orientation.

12.3.2 Auto-zero catalyst replacement

The auto-zero catalyst is supplied in a filter canister; replacing the catalyst is simply a matter of swapping out the old canister for the new.

Follow steps [1] and [2] of the procedure for removing the internal particulate filter to remove the old catalyst.

If the catalyst is being replaced as a result of the COSAMS reporting a catalyst fault (*Sensor fault: CAT*):

- 1] Clear the fault by entering the SDA operator console main menu and select:
*Replace catalyst... > CO sensor (1) > Yes***
- 2] Manually initiate an auto-zero once the COSAMS warm-up period has expired:
*Auto-zero... > CO sensor (1)***

12.3.3 Cabinet breather inspection/replacement

Inspect the cabinet's breather port, externally mounted on the right-hand side of the cabinet – if the central white, sintered section appears to be fouled then the breather should be replaced.



The breather may be removed from the cabinet by unscrewing the plastic nut on the rear. When installing a new breather, ensure that the O-ring is correctly seated in the groove on the back face of the breather.

12.3.4 Removal and replacement of the baseplate assembly

It is necessary to remove the COSAMS baseplate assembly to service/replace some components and also to mount the cabinet on shock isolators.

12.3.4.1 Baseplate assembly removal

- 1] Disconnect the power input connector to isolate the COSAMS from the supply.**
- 2] Open the cabinet and disconnect the tubing at the gas inlet/exhaust ports.**



(The gas inlet/exhaust ports are shown in the photograph on the left, highlighted with arrows)

- 3] Unscrew the outer collar of the circular DC power connector 120° and unplug the connector.**



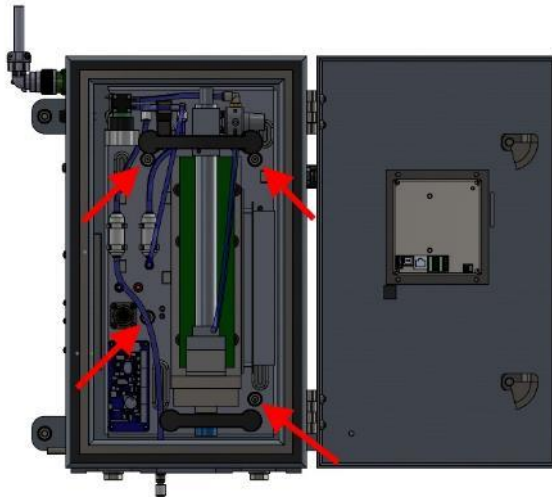
(The circular DC power connector is shown in the photograph on the left, highlighted with an arrow)

- 4] Unplug the SDA operator console power connector and the RS485 connections to the Interface PCB and Output Module PCB (marked *SENS* and *DATA*, respectively).**



(The SDA operator console connectors are shown in the photograph on the left, highlighted with an arrow)

- 5] Remove the four sets of M8 nuts/spring washers/flat washers that retain the baseplate.**

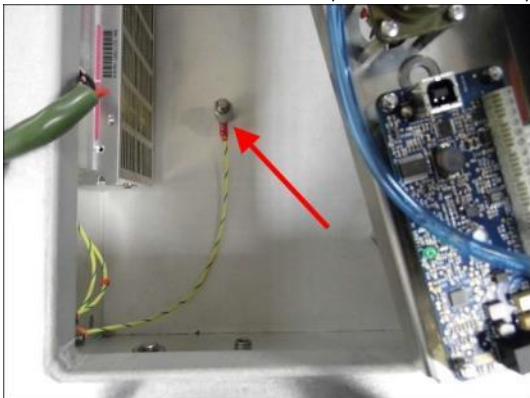


(The M8 retaining nuts and washers are shown in the drawing on the left, highlighted with arrows)

- 6) Withdraw the baseplate assembly from the cabinet, taking particular care not to bump any parts of the GFC CO sensor.**

12.3.4.2 Refitting the baseplate assembly

To refit the baseplate, ensure that the baseplate earth strap is located on the lower-left mounting stud and then follow the removal instructions, section 12.3.4.1, in reverse order.

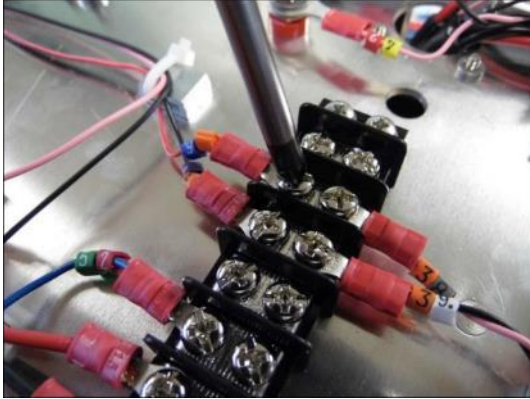


⚠ CAUTION: ENSURE THE EARTH STRAP SITS ON THE MOUNTING STUD BEFORE REFITTING THE BASEPLATE.

12.3.5 Sample pump replacement

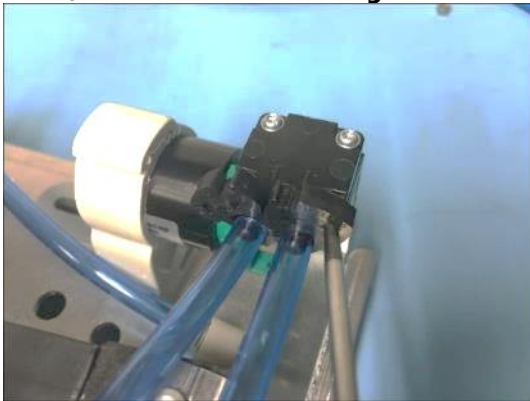
Replacing the sample pump requires removal of the baseplate assembly, as described in section 12.3.4.
With the baseplate removed:

- 7] **Disconnect the pump wiring from the terminal block (Wires 36 & 37) on the rear of the baseplate, remove the three white low smoke cable ties securing the pump wiring and feed through the oval grommet underneath the pump.**



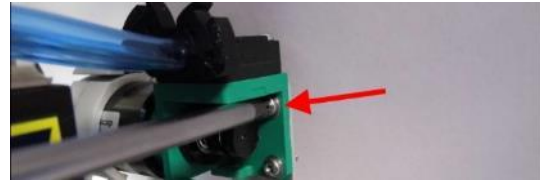
(The pump wiring terminal block is shown in the photograph on the left)

- 8] **Open the tube securing clips by pushing the clip open with a terminal driver to loosen the teeth, then remove the tubing from the inlet (Left spigot) and outlet (Right spigot).**



- 9] **Pop the mount clip open around the pump body.**

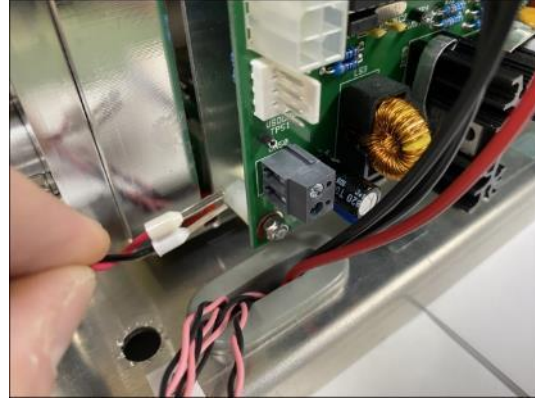
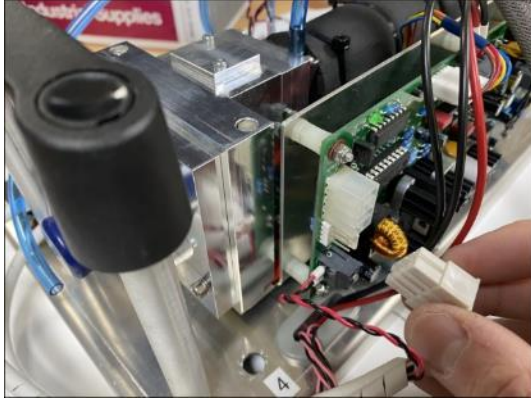
- 10] Remove the two M2.5 x 10mm Pozi Pan Screws, M2.5 spring washers and M2.5 flat washers from the inside face of the pump bracket on the upright using a long (200mm blade length) PZ1 screwdriver, access is via the gap above the flow switch and below the GFC sensor.



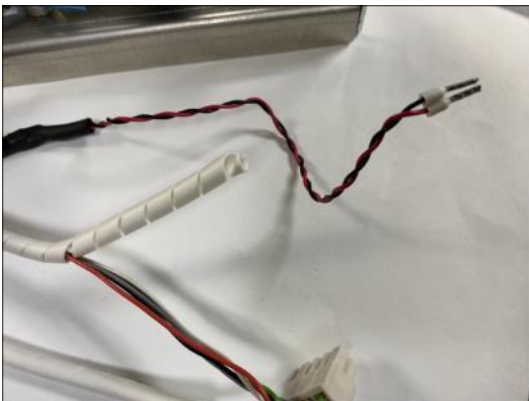
12.3.6 Infra-red source replacement

Replacing the sensor's infra-red source, located at the bottom end of the CO sensor, requires removal of the baseplate assembly, as described in section 12.3.4. With the baseplate removed:

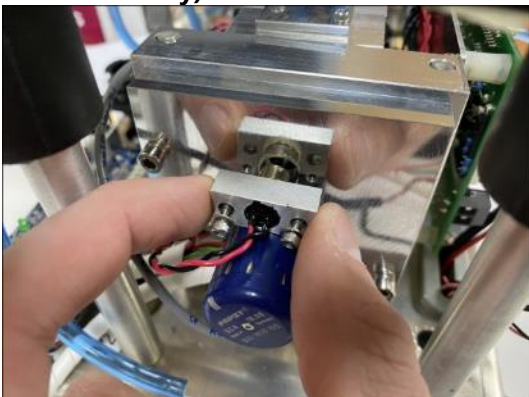
- 1] Disconnect the motor harness connector from the power PCB as shown, then disconnect the source harness from the screw terminal connector on the power PCB.**



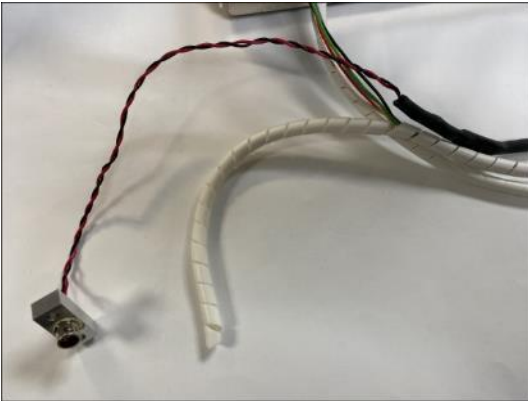
- 2] Unwrap the cable wrap from the motor harness as shown to release the connection end of the IR source harness.**



- 3] Remove the two bolts and washers securing the source to the motor plate (requires a 2mm hex key).**



- 4] Unwrap the cable wrap from the motor harness as shown to release the source end of the IR source harness.



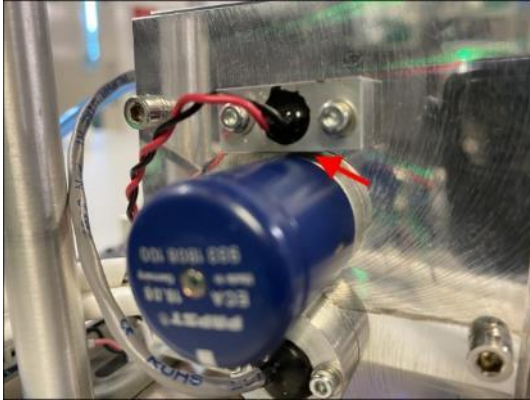
- 5] Fit the replacement IR source assembly and rewrap the cable wrap around the source end and the connection end of the harness as shown.



- 6] Refit the IR source block to the motor plate using the previously removed bolts and washers.

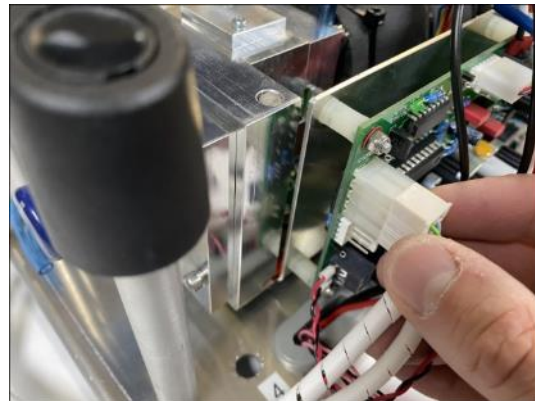
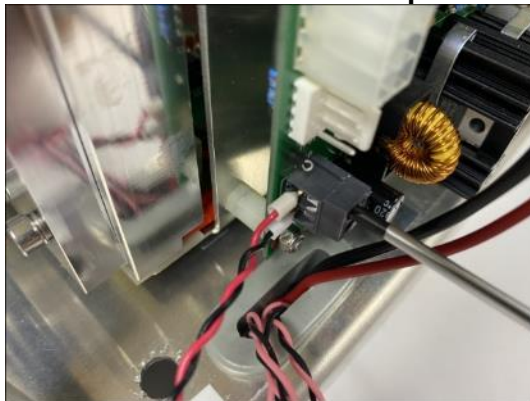


⚠ **CAUTION: THE SOURCE BOLT HOLES ARE OVER-SIZED ALLOWING A HIGH DEGREE OF POSITIONAL VARIABILITY. CARE MUST BE TAKEN TO ENSURE THAT THE SOURCE HOUSING DOES NOT TOUCH THE SENSOR'S MOTOR AS THIS WILL CAUSE THE SENSOR TO MALFUNCTION.**



◆ **CAUTION: THE SOURCE HOUSING
MUST NOT FOUL ON THE MOTOR;
MAINTAIN A GAP OF AT LEAST 0.5MM.**

- 7] Refit the IR source harness to the screw terminal connector on the power PCB, then Refit the motor harness connector to the power PCB.



- 8] Once the COSAMS has been re-assembled, powered-up and the warm-up time has elapsed, calibrate the system (refer to section 12.4.8).

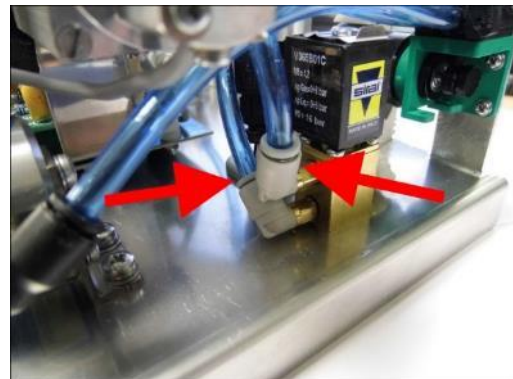
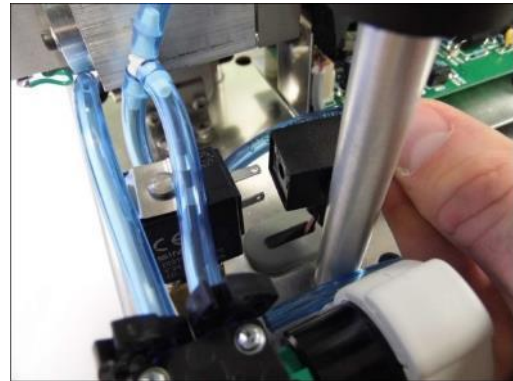
12.4 Non-periodic maintenance

The following tasks are not part of the routine periodic maintenance but are detailed to assist with repair of the COSAMS in the event of an unexpected component failure.

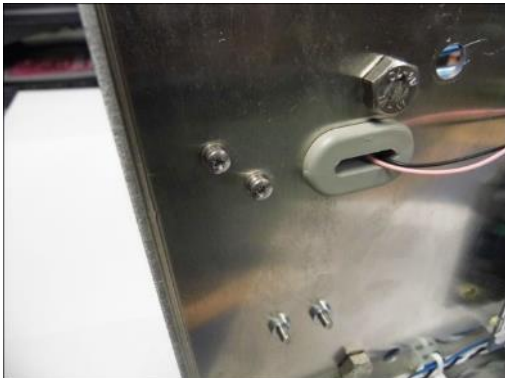
12.4.1 Solenoid valve replacement

Replacing the solenoid valve requires removal of the baseplate assembly, as described in section 12.3.4. With the baseplate removed:

- 1] **Disconnect the solenoid valve electrical connector by unscrewing it from the body of the solenoid valve.**
- 2] **Disconnect the pipework from the push-fit fittings, noting the relative positions for re-assembly.**



- 3] **Undo the M3 mounting hardware from the underside of the baseplate to remove the valve.**



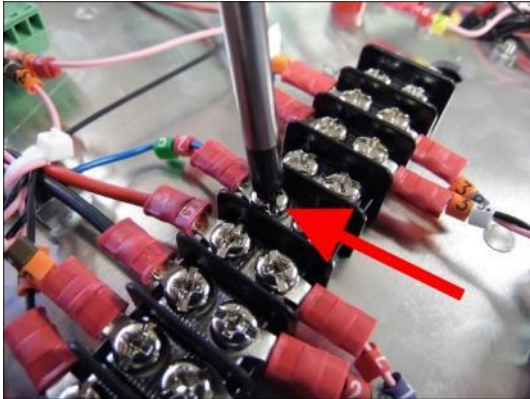
- 4] **Recover the gas fittings from the base of the valve and install in the new valve.**
- 5] **Orientate the gas ports and then mount the new valve on the baseplate.**

6] Refit the pipework and electrical connector.

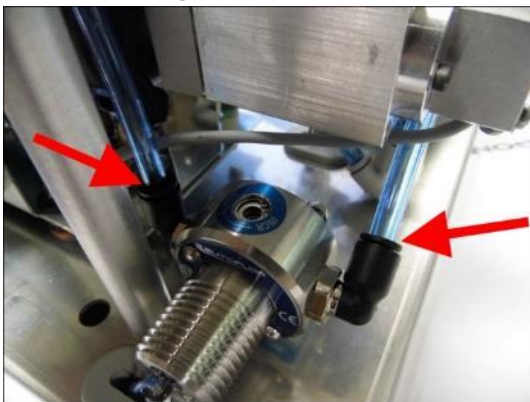
12.4.2 Flow switch replacement

Replacing the flow switch requires removal of the baseplate assembly, as described in section 12.3.4.
With the baseplate removed:

- 1] Remove the three white low smoke cable ties securing the flow switch wiring and disconnect the flow switch wiring from the terminal rail on the underside of the baseplate (Blue wire – 52) & interface PCB on the front of the baseplate (40 & 41), remove the wiring by un-routing it on the underside of the baseplate and feed through the oval grommet under the flow sensor.



- 2] Disconnect the flow switch pipework from the push fit elbows (Pump to 'IN', 'OUT' to GFC sensor inlet) on the flow switch.
- 3] Remove the M4 mounting hardware (Screw & Washer) to allow the flow switch to be removed from the baseplate.



Above: Flow switch pipework and mounting hardware

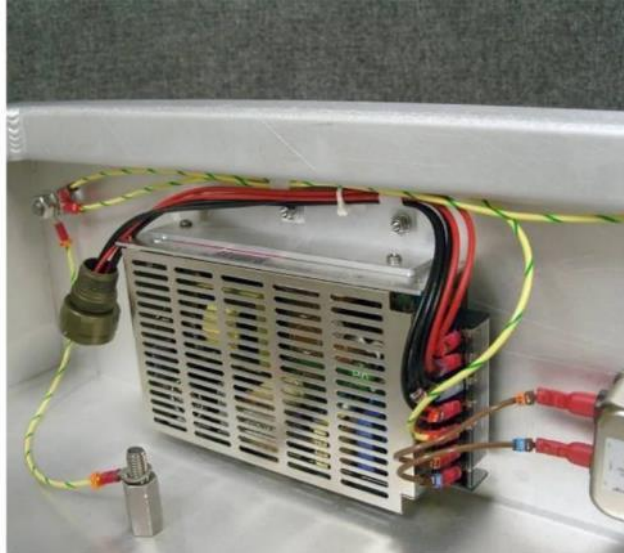
Reverse steps [3] – [1] to install the new flow switch.

12.4.3 Replacing the power supply unit (AC variant)

Replacing the power supply unit (PSU) requires removal of the baseplate assembly, as described in section 12.3.4.

With the baseplate removed:

- 1] Remove the 5 sets of M3 mounting hardware from the left-hand side of the cabinet – the two on the left are M3 x 8mm and screw directly in to the PSU itself, the three on the right are M3 x 16mm and hold the PSU supporting bracket to the cabinet.**

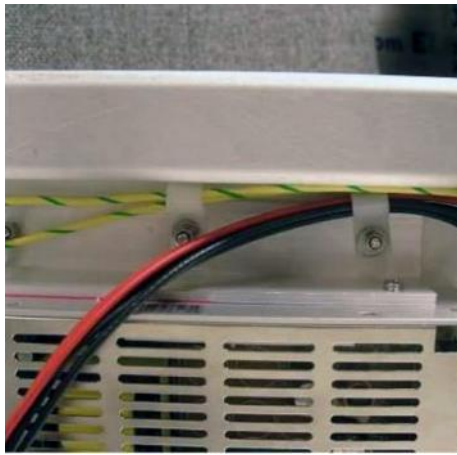


- 2] Unclip the terminal cover and disconnect all of the wiring connections.**
- 3] Withdraw the power supply, and recover the PSU supporting bracket and two mounting screws.**
- 4] Fit the bracket to the new PSU – the screws should be treated with a suitable thread-locking compound, e.g., Loctite 222, or a shake-proof washer should be used to prevent loosening under vibration.**
- 5] Wire up the new PSU as shown and fit the terminal cover:**

PSU terminal	Wire number	Colour
L	16	Brown
N	13	Brown
E	2	Green/Yellow
V-	21	Black
V-	18,19	Black
V+	17	Red
V+	20	Red

- 6] Very loosely fasten the PSU to the cabinet using the two M3 x 8mm screws (again, use either thread-locking compound or a shake-proof washer) to allow alignment of the supporting bracket with its mounting holes. Fit the PSU supporting brackets M3 x 16mm screws with M3 flat washers from the outside of the cabinet and secure with the following hardware internally:**

Mounting screw	Internal fittings/fasteners (in order of fitting)
Top	cable clamp (holds wires 17-21) M4 washer M3 washer M3 nyloc nut
Middle	cable clamp (holds wires 1 & 2) M4 washer M3 washer M3 nyloc nut
Bottom	M3 nyloc nut



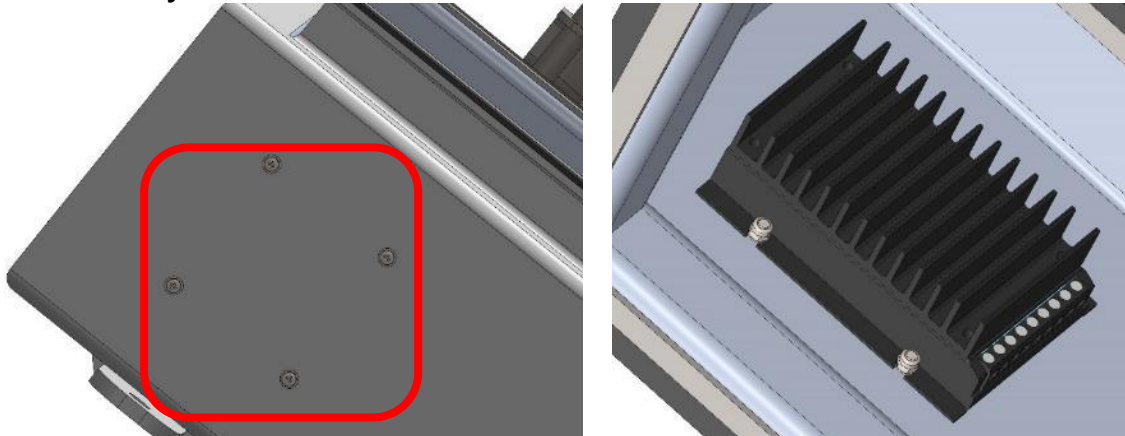
7] Fully tighten all hardware.

12.4.4 Replacing the power supply unit (DC variant)

Replacing the power supply unit (PSU) requires removal of the baseplate assembly, as described in section 12.3.4.

With the baseplate removed:

- 1] **Remove the 4 sets of M3 mounting hardware from the top left-hand side of the cabinet – they are all M3 x12 Pozi Pan screws with M3 flat washers on the external face, secured with M3 flat washers & M3 Nyloc nuts on the internal face.**



- 2] **Disconnect all of the wiring connections from the screw terminal block on the PSU.**
- 3] **Withdraw the power supply.**
- 4] **Wire up the new PSU as detailed below and fit the terminal cover:**

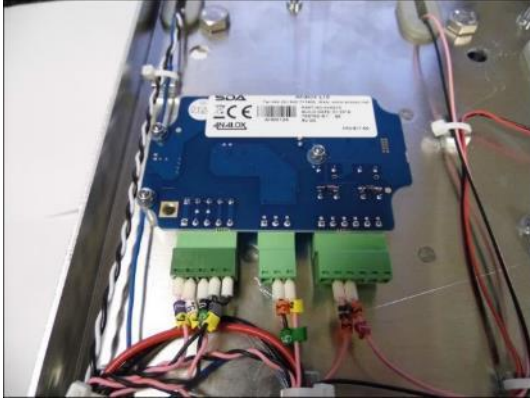
PSU terminal No	Wire number	Colour
1 +Vi	NC	NC
2 +Vi	13	Red
3 -Vi	NC	NC
4 -Vi	16	Black
5 Ctrl	NC	NC
6 +Vo	17 & 20	Red
7 -Vo	18, 19 & 21	Black
8 Trim1	NC	NC
9 Trim2	NC	NC

- 5] **Refit the PSU using the 4 sets of M3 mounting hardware from the left hand side of the cabinet – they are all M3 x12 Pozi Pan Screws with M3 flat washers on the external face, secured with M3 flat washers & M3 Nyloc nuts on the internal face, secure the PSU in place.**

12.4.5 Replacing the SDA Output Module PCB

Replacing the SDA Output Module PCB requires removal of the baseplate assembly, as described in 12.3.4. With the baseplate removed:

- 1] With the baseplate upside down, unplug the electrical connections from the PCB.**



- 2] Remove the PCB by unscrewing the three M2.5 Nyloc nuts and nylon washers (This will also remove the insulating pillars underneath the PCB from the baseplate).**
- 3] Remove the insulated pillars from the PCB and refit to the baseplate.**



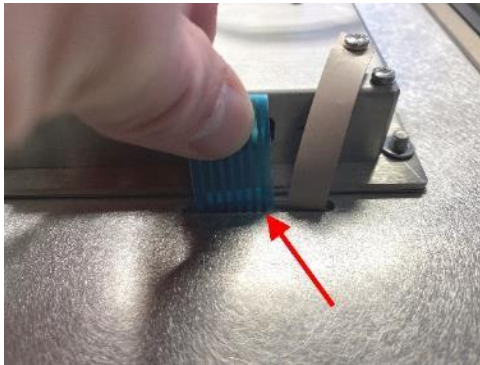
- 4] Refit the PCB to the pillars and secure with the M2.5 Nylon washers and Nyloc Nuts.**
- 5] Refit the electrical connectors.**

12.4.6 Replacing SDA Operator Console membrane label

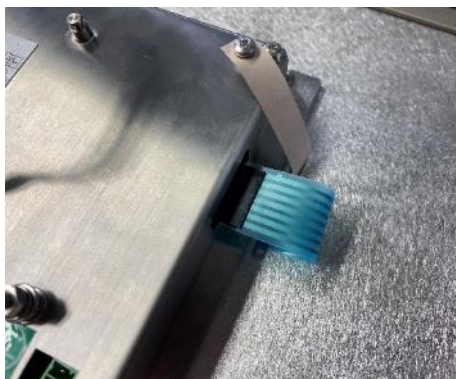
- 1] Loosen the grub screw (2mm hex key required) securing the rotary encoder knob and remove the knob from the encoder shaft.



- 2] Remove the 2 encoder retaining nuts and pass the encoder back through the panel.
- 3] Disconnect the ribbon cable, unfasten the shield tag and remove the adhesive (used to prevent chafing of the wiring) from the slot in the cabinet door.



- 4] Peel the membrane from the cabinet door and clean any remnants of adhesive from the door.
- 5] Remove the protective film from the rear of the replacement label. Feed the ribbon cable and shield tag through the slot in the cabinet door, align the membrane with the LCD and encoder hole and affix the membrane to the door.
- 6] Connect the ribbon cable to the 7 way right angle header coming through the side of the SDA rear cover.

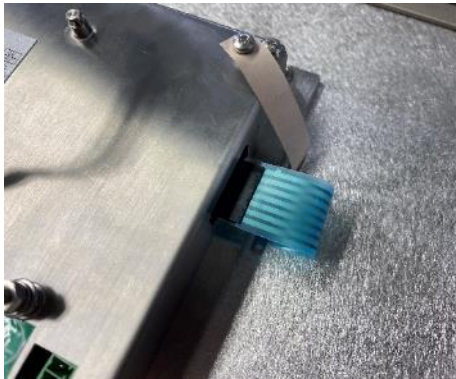


- 7] Cut a small slot in the shield tag and fit over the stud on the rear top-right corner of the SDA with one of the Nord lock washers above and one below.

- 8] Run a bead of glue/sealant, e.g., silicone sealant, along the cable slot to fix the ribbon cable and shield tag in place and prevent chafing against the edge of the slot.
- 9] Refit the rotary encoder and knob. Ensure that both nuts are used to mount the encoder, this prevents damage occurring to the device in the event of the knob being subject to an impact.

12.4.7 Replacing the SDA Operator Console

- 1] Disconnect the SDA electrical connections:
 - Unplug the ribbon cable connection to the membrane label and undo the shield tag from the SDA's upper earth stud.
 - Unplug the 5S3, output module and power connectors.
 - Disconnect the earth wire attached to the lower earth stud.
 - Carefully peel away the adhesive around the ribbon cable attached to the rotary encoder and unplug the encoder.
- 2] Undo the four nuts fastening the console to the mounting studs on the cabinet door and remove the console.
- 3] Mount the new SDA console on to the mounting studs, fit the nuts and washers and re-make all the electrical connections - Connect the ribbon cable to the 7 way right angle header coming through the side if the SDA rear cover.
- 4] Connect the shield tag and fit over the stud on the rear top-right corner of the SDA with one of the Nord lock washers above and one below.



- 5] Apply a bead of adhesive, e.g., silicone sealant, to the encoder/ribbon cable connector joint to prevent accidental detachment.

12.4.8 CO sensor calibration

There are two methods of CO sensor calibration:

- a) 'Fine' calibration via the SDA operator console to maintain optimal performance as the sensor output drifts slightly as the sensor ages. This procedure is described in section 8.
- b) 'Coarse' calibration is required when sensor output drift has become significant; the GFC CO sensor's potentiometers must be adjusted to return the sensor's output to the nominal levels expected by the interface PCB. 'Coarse' calibration should always be followed by a 'fine' calibration.

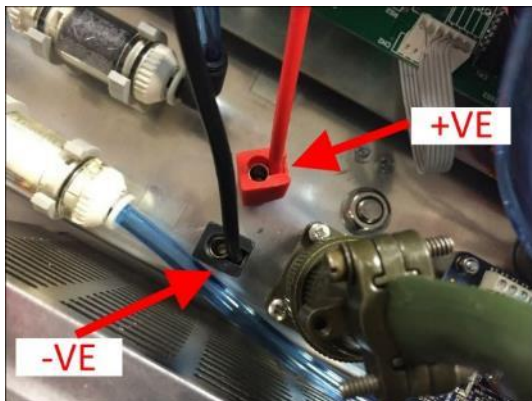
The 'coarse' calibration procedure should be performed after servicing the COSAMS.

12.4.8.1 'Coarse' calibration procedure

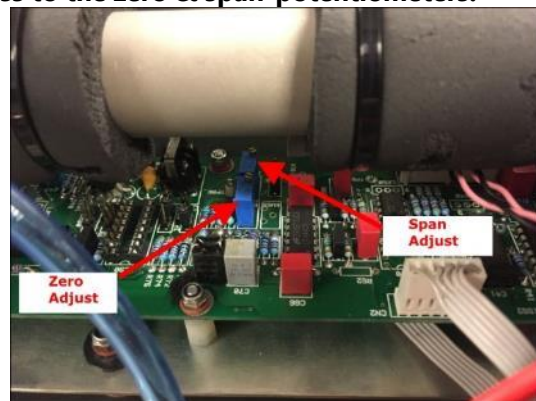
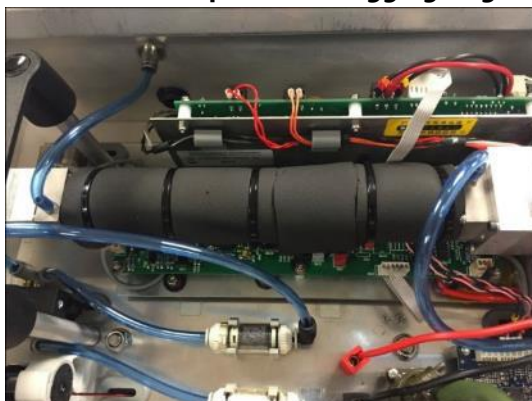
'Coarse' calibration is best performed on a fully warmed-up system.

NOTE: THE CO SENSOR IS SENSITIVE TO CHANGES IN TEMPERATURE; FOR BEST RESULTS, TRY TO MINIMISE THE PERIODS WHEN THE ENCLOSURE DOOR IS OPEN TO MAKE ADJUSTMENTS.

- 1] Connect a DVM (Digital Volt Meter) set to Volts dc to the red (+VE) & black (-VE) test points located next to the ITT Cannon 7 way panel connector on the baseplate using 4mm unshrouded test leads.

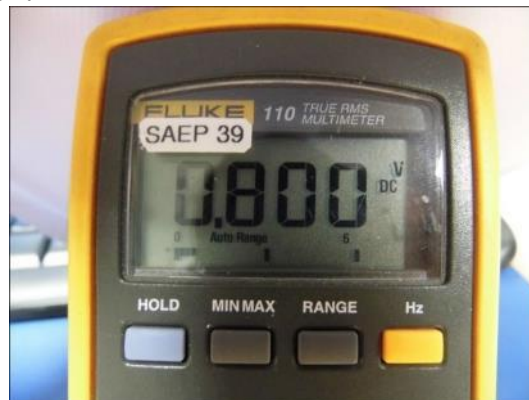
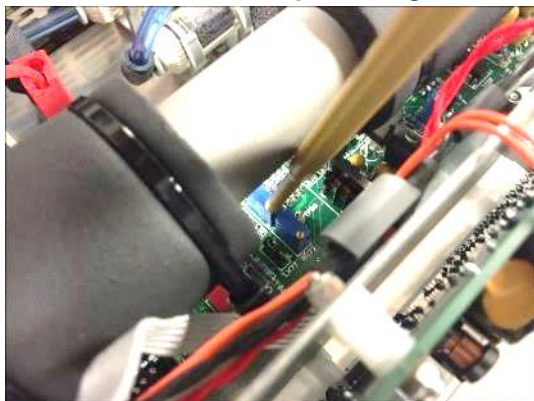


- 2] Remove central portion of lagging to gain access to the zero & span potentiometers:



- 3] Apply zero gas to the sensor, as described in the fine calibration procedure (section 8).
- 4] Leave the gas to flow for approximately 3 minutes and then measure the CO sensor output signal using the DVM across test points (Red +VE) and (Black -VE) on the baseplate.

- 5] Adjust the GFC's zero potentiometer using a trimming tool, located beneath the optical bench, to achieve a sensor output voltage of $0.8 \pm 0.05V$.



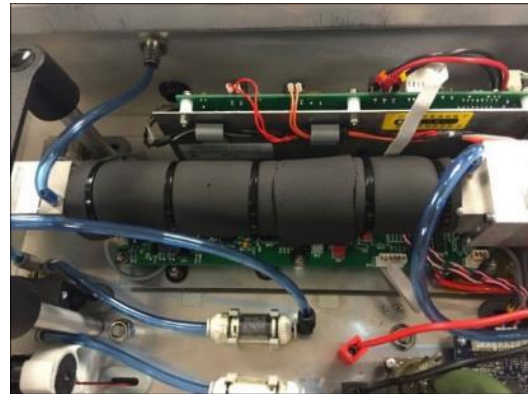
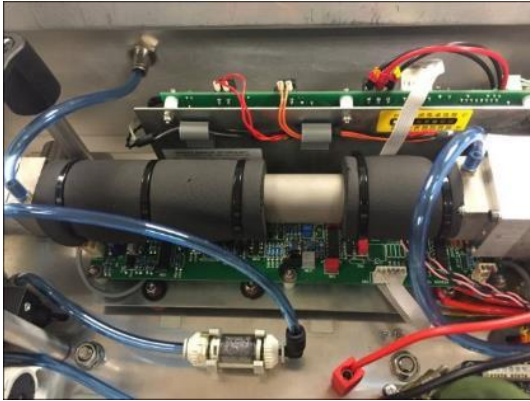
- 6] Swap to span gas (Recommended at 150ppm CO in air), as described in the fine calibration procedure (section 8).

- 7] Adjust the span potentiometer using a trimming tool to achieve a sensor output voltage of $2.225 \pm 0.05 V$ dc, this is dependent on using a 150ppm CO in air span gas. If using a 200ppm CO in air span gas the output would be $\sim 2.7 \pm 0.05 V$ dc.



- 8] Repeat steps [2] through [6] until no further adjustment of the potentiometers is required.

- 9] **Replace central portion of lagging.**



- 10] **Remove the test leads from the test points on the baseplate and shut the cabinet door.**
11] **Allow the system temperature to stabilise for approximately 20 minutes and then perform a fine calibration, according to section 8.**

13 Warranty

TBD

14 Fault reporting to Analox

In the event of a fault arising, the following table may be of use when reporting the fault to Analox. Please complete whichever sections are believed to be relevant to the fault and return a copy to Analox - contact details can be found on the front page of this manual.

Date	
-------------	--

Company/institution name	
Customer contact	
Address	
Country	
Telephone number	
Mobile telephone number	
Email address	

COSAMS serial no.	
CO sensor serial no.	
SDA console serial no.	
System Operating Voltage	
Description of fault	

15 Specifications

15.1 Mechanical specifications

Nominal cabinet dimensions (mm): h x w x d, exc. mounting lugs	479 x 280 x 175
Nominal system dimensions (mm): h x w x d	600 x 360 x 200
Weight (kg)	11
Cabinet material	Aluminium

15.2 Electrical specifications (AC variant)

Electrical supply	115V AC 60Hz
Max. power consumption	90W
Fuse rating (F1, F2)	20mm, 2.5A anti-surge
Signal output	4-20mA
EMC compliance	MIL-STD-461F
ESD compliance	EN 61000-4-2

15.3 Electrical specifications (DC variant)

Electrical supply	24V DC
Max. power consumption	55W (During warmup) 40W (During normal operation)
Fuse rating (F1, F2)	38x10mm, 16A anti-surge
Signal output	4-20mA
EMC compliance	MIL-STD-461F
ESD compliance	EN 61000-4-2

15.4 Environmental specifications

Operating temperature range	0 to +45°C
Storage temperature	-40 to +70°C
Operating pressure range	700 to 1300 hPa
Extended pressure range¹	600 to 700 hPa
Storage/transport pressure range	300 to 1400 hPa
Operating humidity range	0 to 80 %RH
Extended humidity range (up to 1 hr)	80 to 100 %RH
Storage humidity range	0 to 80 %RH (temporary max. 100 %RH)
Max. roll angle (constant)²	15°
Max. roll angle (temporary)	45°
Max. pitch angle (constant)²	10°
Max. pitch angle (temporary)	30°
Shock	Tested at 22g, 20ms (half sine) without shock isolation
Vibration	NATO STANAG 4138

¹ Degraded performance is permissible over the pressure range 600-800hPa.

² The system shall operate at any legal combination of roll & pitch angles and continue to satisfy the specified accuracy requirement.

15.5 Performance specifications

CO measuring range	0 – 200 ppm
Repeatability, measured at RTP	± (1 ppm CO + 1 display count)
Accuracy across normal operating environmental envelope	±5% full scale (equivalent to ± 10 ppm)
Zero drift	±1 ppm CO / day
Cross-sensitivity to hydrogen	2 %vol H2 < 1ppm CO
Cross sensitivity to carbon dioxide	5%vol CO2 < 1ppm CO
Response time	T ₉₀ < 60s

16 Disposal

16.1 WEEE statement



According to WEEE regulation this electronic product cannot be placed in household waste bins. Please check local regulations for information on the disposal of electronic products in your area. Analox will provide a disposal service if this is beneficial to the customer. Analox are registered for the disposal of WEEE in the UK through the Environment Agency (2013 Registration number WEE/KE0043SY).

16.2 Catalyst disposal

Dispose of contents/container in accordance with applicable local regulations.

Appendix A PremiOx Gold safety datasheet

MATERIAL SAFETY DATASHEET. Premier Chemicals Ltd



SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: PremiOx Gold Catalyst - Gold nanoclusters supported on Titanium Dioxide

SUPPLIER: Premier Chemicals Ltd

ADDRESS: PO Box 583

Huntingdon, PE29 9EF

United Kingdom

Product Use: Oxidation catalyst

Emergency Contact Number: + 44 1480 878134

SECTION 2: INGREDIENTS

<u>Ingredient</u>	<u>% by Wt</u>
Titanium oxide	> 95%
Gold nanoclusters	<5 %

SECTION 3: HAZARDS IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Specific physical form: Pellets

Odour, Colour: Odourless, Purple

General Physical Form: Solid

3.2 POTENTIAL HEALTH EFFECTS

Eye contact:

Mechanical eye irritation: Signs / symptoms may include pain, redness, tearing and corneal abrasion.

Skin contact:

Mechanical skin irritation: Signs / symptoms may include redness, abrasion, pain and itching.

Inhalation:

Respiratory Tract Irritation: Signs / symptoms may include cough, sneezing, nasal discharge, headache, and nose and throat pain.

Ingestion:

No health effects are expected.

Classification of the substance or mixture

Not a hazardous substance or mixture according to Regulation (EC) No.1272/2008.

This substance is not classified as dangerous according to Directive 67/548/EEC.

MATERIAL SAFETY DATASHEET. Premier Chemicals Ltd

SECTION 4: FIRST AID MEASURES

4.1 DESCRIPTION OF FIRST AID MEASURES

In case of eye contact:

Flush eyes with water as a precaution.

In case of skin contact:

Wash off with soap and plenty of water.

If inhaled:

If breathed in, move person into fresh air. If not breathing, give artificial respiration.

If Swallowed:

Never give anything by mouth to an unconscious person. Rinse mouth with water.

SECTION 5: FIRE FIGHTING MEASURES

5.1 FLAMMABLE PROPERTIES:

Auto-ignition temperature	>800°C
Flash point	Not applicable
Flammable Limits - LEL	Not applicable
Flammable Limits – UEL	Not applicable

5.2 EXTINGUISHING MEDIA

Use fire extinguishers with class B extinguishing agents (e.g., dry chemical, carbon dioxide)

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1 PERSONAL PRECAUTIONS, PROTECTIVE EQUIPEMNT AND EMERGENCY PROCEDURES

Avoid dust formation. Avoid breathing vapours, mist or gas. For personal protection see section 8.

6.2 ENVIRONMENTAL PRECAUTIONS

Do not let product enter drains.

6.3 METHODS AND MATERIALS FOR CONTAINMENT AND CLEANING UP

Sweep up and shovel. Keep in suitable, closed containers for disposal.

SECTION 7: HANDLING AND STORAGE

7.1 PRECAUTIONS FOR SAFE HANDLING

Provide appropriate exhaust ventilation at places where dust is formed. If ventilation is not adequate, use respiratory protection equipment.

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7.2 CONDITIONS FOR SAFE STORAGE, INCLUDING ANY INCOMPATIBILITIES

Store in cool, dry place and away from oxidizing agents. Keep container tightly closed in a dry and well-ventilated place.

SECTION 8: PERSONAL PROTECTION

8.1 PERSONAL PROTECTIVE EQUIPMENT (PPE)

8.1.1 Eye/Face protection

The following eye protection(s) are recommended: **Safety glasses with side shields.**

8.1.2 Skin protection

Handle with gloves. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

8.1.3 Body protection

The type of protective equipment must be selected according to the concentration and amount of the dangerous substance and the specific workplace.

8.1.4 Respiratory protection

Use dust / particulate masks.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Specific, physical form:	Powder, granule
Odor, color:	Odorless, grey
General Physical form:	Solid
Auto-ignition temperature:	> 400°C
Flash point	Not applicable
Flammable Limits - LEL	Not applicable
Flammable Limits – UEL	Not applicable
Density	No data available
pH	No data available
Solubility in water	Insoluble

SECTION 10: STABILITY AND REACTIVITY

10.1 Reactivity

No data available.

10.2 Chemical stability

Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions

No data available.

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10.4 Conditions to avoid

No data available.

10.5 Incompatible materials

Strong oxidizing materials.

10.6 Hazardous decomposition products

Other decomposition products -No data available.

In the event of fire: See section 5.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Please contact the address listed on the first page of the MSDS for Toxicological information on this material and/or its components.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION: Not determined.

CHEMICAL FATE INFORMATION: Not determined.

SECTION 13: DISPOSAL CONSIDERATIONS

DISPOSAL METHOD:

Contact special disposal companies. Dispose of in accordance with Local Authority requirements. Recover and reclaim or recycle, if practical.

SECTION 14: TRANSPORT

General: Not classified as dangerous for transport

UN No. 0

Road transport notes: Not classified as dangerous for road transport

Rail transport notes: Not classified as dangerous for rail transport

Sea transport notes: Not classified as dangerous for sea transport

Air transport notes : Not classified as dangerous for air transport

SECTION 15: REGULATORY INFORMATION

In accordance with local and national regulations.

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SECTION 16: OTHER INFORMATION

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Appendix B Nanaucat safety data sheet

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Safety Data Sheet

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SECTION 1: Identification

1.1. Product identifier

3M Gold Catalyst AUC-16-1

Product Identification Numbers

70-0715-3439-3

1.2. Recommended use and restrictions on use

Recommended use

Catalyst

1.3. Supplier's details

MANUFACTURER:	3M
DIVISION:	Personal Safety Division
ADDRESS:	3M Center, St. Paul, MN 55144-1000, USA
Telephone:	1-888-3M HELPS (1-888-364-3577)

1.4. Emergency telephone number

1-800-364-3577 or (651) 737-6501 (24 hours)

SECTION 2: Hazard identification

2.1. Hazard classification

Carcinogenicity: Category 2.

2.2. Label elements

Signal word

Warning

Symbols

Health Hazard |

Pictograms

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Hazard Statements

Suspected of causing cancer.

Precautionary Statements

Prevention:

Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Wear protective gloves.

Response:

IF exposed or concerned: Get medical advice/attention.

Storage:

Store locked up.

Disposal:

Dispose of contents/container in accordance with applicable local/regional/national/international regulations.

2.3. Hazards not otherwise classified

None.

1% of the mixture consists of ingredients of unknown acute oral toxicity.

SECTION 3: Composition/information on ingredients

Ingredient	C.A.S. No.	% by Wt
ACTIVATED CARBON	7440-44-0	80 - 100 Trade Secret *
ANATASE TITANIUM DIOXIDE	1317-70-0	5 - 20 Trade Secret *
GOLD	7440-57-5	< 1 Trade Secret *

*The specific chemical identity and/or exact percentage (concentration) of this composition has been withheld as a trade secret.

SECTION 4: First aid measures

4.1. Description of first aid measures

Inhalation:

Remove person to fresh air. If you feel unwell, get medical attention.

Skin Contact:

Wash with soap and water. If signs/symptoms develop, get medical attention.

Eye Contact:

Flush with large amounts of water. Remove contact lenses if easy to do. Continue rinsing. If signs/symptoms persist, get medical attention.

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If Swallowed:

Rinse mouth. If you feel unwell, get medical attention.

4.2. Most important symptoms and effects, both acute and delayed

See Section 11.1. Information on toxicological effects.

4.3. Indication of any immediate medical attention and special treatment required

Not applicable

SECTION 5: Fire-fighting measures

5.1. Suitable extinguishing media

In case of fire: Use a fire fighting agent suitable for ordinary combustible material such as water or foam to extinguish.

5.2. Special hazards arising from the substance or mixture

None inherent in this product.

Hazardous Decomposition or By-Products

<u>Substance</u>	<u>Condition</u>
Carbon monoxide	During Combustion
Carbon dioxide	During Combustion

5.3. Special protective actions for fire-fighters

No unusual fire or explosion hazards are anticipated.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Evacuate area. Ventilate the area with fresh air. For large spill, or spills in confined spaces, provide mechanical ventilation to disperse or exhaust vapors, in accordance with good industrial hygiene practice. Warning! A motor could be an ignition source and could cause flammable gases or vapors in the spill area to burn or explode. Refer to other sections of this SDS for information regarding physical and health hazards, respiratory protection, ventilation, and personal protective equipment.

6.2. Environmental precautions

Avoid release to the environment.

6.3. Methods and material for containment and cleaning up

Collect as much of the spilled material as possible. Use wet sweeping compound or water to avoid dusting. Sweep up. Place in a closed container approved for transportation by appropriate authorities. Clean up residue. Seal the container. Dispose of collected material as soon as possible.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

For industrial or professional use only. Do not handle until all safety precautions have been read and understood. Avoid breathing dust/fume/gas/mist/vapors/spray. Do not get in eyes, on skin, or on clothing. Do not eat, drink or smoke when using this product. Wash thoroughly after handling. Avoid contact with oxidizing agents (eg. chlorine, chromic acid etc.) Use personal protective equipment (gloves, respirators, etc.) as required.

7.2. Conditions for safe storage including any incompatibilities

Store away from oxidizing agents.

SECTION 8: Exposure controls/personal protection

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8.1. Control parameters

Occupational exposure limits

Ingredient	C.A.S. No.	Agency	Limit type	Additional Comments
ACTIVATED CARBON	7440-44-0	Chemical Manufacturer Rec Guid	TWA:3 fiber/cc	
Graphite	7440-44-0	Amer Conf of Gov. Indust. Hyg.	TWA(respirable fraction):2 mg/m3	
Graphite	7440-44-0	US Dept of Labor - OSHA	TWA:15 millions of particles/cu. ft.	
GRAPHITE SYNTHETIC	7440-44-0	US Dept of Labor - OSHA	TWA(as total dust):15 mg/m3;TWA(respirable fraction):5 mg/m3	

Amer Conf of Gov. Indust. Hyg. : American Conference of Governmental Industrial Hygienists
 American Indust. Hygiene Assoc : American Industrial Hygiene Association
 Chemical Manufacturer Rec Guid : Chemical Manufacturer's Recommended Guidelines
 US Dept of Labor - OSHA : United States Department of Labor - Occupational Safety and Health Administration
 TWA: Time-Weighted-Average
 STEL: Short Term Exposure Limit
 CEIL: Ceiling

8.2. Exposure controls

8.2.1. Engineering controls

Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures to below relevant Exposure Limits and/or control dust/fume/gas/mist/vapors/spray. If ventilation is not adequate, use respiratory protection equipment.

8.2.2. Personal protective equipment (PPE)

Eye/face protection

Select and use eye/face protection to prevent contact based on the results of an exposure assessment. The following eye/face protection(s) are recommended:
 Safety Glasses with side shields

Skin/hand protection

No chemical protective gloves are required.

Respiratory protection

An exposure assessment may be needed to decide if a respirator is required. If a respirator is needed, use respirators as part of a full respiratory protection program. Based on the results of the exposure assessment, select from the following respirator type(s) to reduce inhalation exposure:
 Half facepiece or full facepiece air-purifying respirator suitable for particulates

For questions about suitability for a specific application, consult with your respirator manufacturer.

SECTION 9: Physical and chemical properties
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9.1. Information on basic physical and chemical properties

General Physical Form: Solid
Specific Physical Form: Granule

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Odor, Color, Grade:	Odorless, grey, granular.
Odor threshold	<i>No Data Available</i>
pH	<i>Not Applicable</i>
Melting point	<i>Not Applicable</i>
Boiling Point	<i>Not Applicable</i>
Flash Point	No flash point
Evaporation rate	<i>Not Applicable</i>
Flammability (solid, gas)	Not Classified
Flammable Limits(LEL)	<i>Not Applicable</i>
Flammable Limits(UEL)	<i>Not Applicable</i>
Vapor Pressure	<i>Not Applicable</i>
Vapor Density	<i>Not Applicable</i>
Density	0.42 - 0.48 g/cm3 [<i>Details: packing density</i>]
Specific Gravity	1.8 - 2.1 [<i>Ref Std: WATER=1</i>]
Solubility in Water	Nil
Solubility- non-water	<i>No Data Available</i>
Partition coefficient: n-octanol/ water	<i>Not Applicable</i>
Autoignition temperature	>=250 °C
Decomposition temperature	<i>No Data Available</i>
Viscosity	<i>Not Applicable</i>
VOC Less H2O & Exempt Solvents	<i>Not Applicable</i>

SECTION 10: Stability and reactivity

10.1. Reactivity

This material may be reactive with certain agents under certain conditions - see the remaining headings in this section.

10.2. Chemical stability

Stable.

10.3. Possibility of hazardous reactions

Hazardous polymerization will not occur.

10.4. Conditions to avoid

None known.

10.5. Incompatible materials

Strong oxidizing agents

10.6. Hazardous decomposition products

Substance
None known.

Condition

Refer to section 5.2 for hazardous decomposition products during combustion.

SECTION 11: Toxicological information

The information below may not be consistent with the material classification in Section 2 if specific ingredient

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classifications are mandated by a competent authority. In addition, toxicological data on ingredients may not be reflected in the material classification and/or the signs and symptoms of exposure, because an ingredient may be present below the threshold for labeling, an ingredient may not be available for exposure, or the data may not be relevant to the material as a whole.

11.1. Information on Toxicological effects

Signs and Symptoms of Exposure

Based on test data and/or information on the components, this material may produce the following health effects:

Inhalation:

Respiratory Tract Irritation: Signs/symptoms may include cough, sneezing, nasal discharge, headache, hoarseness, and nose and throat pain.

Skin Contact:

Mechanical Skin irritation: Signs/symptoms may include abrasion, redness, pain, and itching.

Eye Contact:

Mechanical eye irritation: Signs/symptoms may include pain, redness, tearing and corneal abrasion.

Ingestion:

Gastrointestinal Irritation: Signs/symptoms may include abdominal pain, stomach upset, nausea, vomiting and diarrhea.

Carcinogenicity:

Contains a chemical or chemicals which can cause cancer.

Ingredient	C.A.S. No.	Class Description	Regulation
ANATASE TITANIUM DIOXIDE	1317-70-0	Grp. 2B: Possible human carc.	International Agency for Research on Cancer

Toxicological Data

If a component is disclosed in section 3 but does not appear in a table below, either no data are available for that endpoint or the data are not sufficient for classification.

Acute Toxicity

Name	Route	Species	Value
Overall product	Ingestion		No data available; calculated ATE > 5,000 mg/kg
ANATASE TITANIUM DIOXIDE	Dermal	Rabbit	LD50 > 10,000 mg/kg
ANATASE TITANIUM DIOXIDE	Inhalation-Dust/Mist (4 hours)	Rat	LC50 > 6.82 mg/l
ANATASE TITANIUM DIOXIDE	Ingestion	Rat	LD50 > 10,000 mg/kg

ATE = acute toxicity estimate

Skin Corrosion/Irritation

Name	Species	Value
ANATASE TITANIUM DIOXIDE	Rabbit	No significant irritation

Serious Eye Damage/Irritation

Name	Species	Value
ANATASE TITANIUM DIOXIDE	Rabbit	No significant irritation

Skin Sensitization

Name	Species	Value
ANATASE TITANIUM DIOXIDE	Human and animal	Not sensitizing

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Respiratory Sensitization

Name	Species	Value

Germ Cell Mutagenicity

Name	Route	Value
ANATASE TITANIUM DIOXIDE	In Vitro	Not mutagenic
ANATASE TITANIUM DIOXIDE	In vivo	Not mutagenic

Carcinogenicity

Name	Route	Species	Value
ANATASE TITANIUM DIOXIDE	Ingestion	Multiple animal species	Not carcinogenic
ANATASE TITANIUM DIOXIDE	Inhalation	Rat	Carcinogenic

Reproductive Toxicity

Reproductive and/or Developmental Effects

Name	Route	Value	Species	Test Result	Exposure Duration

Target Organ(s)

Specific Target Organ Toxicity - single exposure

Name	Route	Target Organ(s)	Value	Species	Test Result	Exposure Duration

Specific Target Organ Toxicity - repeated exposure

Name	Route	Target Organ(s)	Value	Species	Test Result	Exposure Duration
ANATASE TITANIUM DIOXIDE	Inhalation	respiratory system	Some positive data exist, but the data are not sufficient for classification	Rat	LOAEL 0.010 mg/l	2 years
ANATASE TITANIUM DIOXIDE	Inhalation	pulmonary fibrosis	All data are negative	Human	NOAEL Not available	occupational exposure

Aspiration Hazard

Name	Value

Please contact the address or phone number listed on the first page of the SDS for additional toxicological information on this material and/or its components.

SECTION 12: Ecological information

Ecotoxicological information

Please contact the address or phone number listed on the first page of the SDS for additional ecotoxicological information on this material and/or its components.

Chemical fate information

Please contact the address or phone number listed on the first page of the SDS for additional chemical fate information on this material and/or its components.

SECTION 13: Disposal considerations

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13.1. Disposal methods

Dispose of contents/ container in accordance with the local/regional/national/international regulations.

Incinerate in a permitted waste incineration facility. Proper destruction may require the use of additional fuel during incineration processes. As a disposal alternative, utilize an acceptable permitted waste disposal facility. Empty drums/barrels/containers used for transporting and handling hazardous chemicals (chemical substances/mixtures/preparations classified as Hazardous as per applicable regulations) shall be considered, stored, treated & disposed of as hazardous wastes unless otherwise defined by applicable waste regulations. Consult with the respective regulating authorities to determine the available treatment and disposal facilities.

EPA Hazardous Waste Number (RCRA): Not regulated

SECTION 14: Transport Information

For Transport Information, please visit <http://3M.com/Transportinfo> or call 1-800-364-3577 or 651-737-6501.

SECTION 15: Regulatory information

15.1. US Federal Regulations

Contact 3M for more information.

311/312 Hazard Categories:

Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No Immediate Hazard - No Delayed Hazard - Yes

15.2. State Regulations

Contact 3M for more information.

15.3. Chemical Inventories

The components of this material are in compliance with the provisions of Australia National Industrial Chemical Notification and Assessment Scheme (NICNAS). Certain restrictions may apply. Contact the selling division for additional information.

The components of this product are in compliance with the new substance notification requirements of CEPA.

The components of this material are in compliance with the China "Measures on Environmental Management of New Chemical Substance". Certain restrictions may apply. Contact the selling division for additional information.

The components of this material are in compliance with the provisions of the Korean Toxic Chemical Control Law. Certain restrictions may apply. Contact the selling division for additional information.

The components of this material are in compliance with the provisions of Philippines RA 6969 requirements. Certain restrictions may apply. Contact the selling division for additional information.

The components of this product are in compliance with the chemical notification requirements of TSCA.

Contact 3M for more information.

15.4. International Regulations

Contact 3M for more information.

This SDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

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SECTION 16: Other information

NFPA Hazard Classification

Health: 1 Flammability: 1 Instability: 0 Special Hazards: None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

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