Evolution Series

CM2010 Ozone Analyser

Service Manual

CE

Regent House, Wolseley Road
Kempston, Bedford
England MK42 7JY

Tel : + 44(0) 1234 844100
Fax: + 44(0) 1234 841490

Email info@casellamonitor.com

HB4016-02
Mar - 2011

Printed in the UK

Contents

1 Installation

1.1 Initial Check

Verify that the serial number label on the documentation and the serial number(s) on the analyser match.

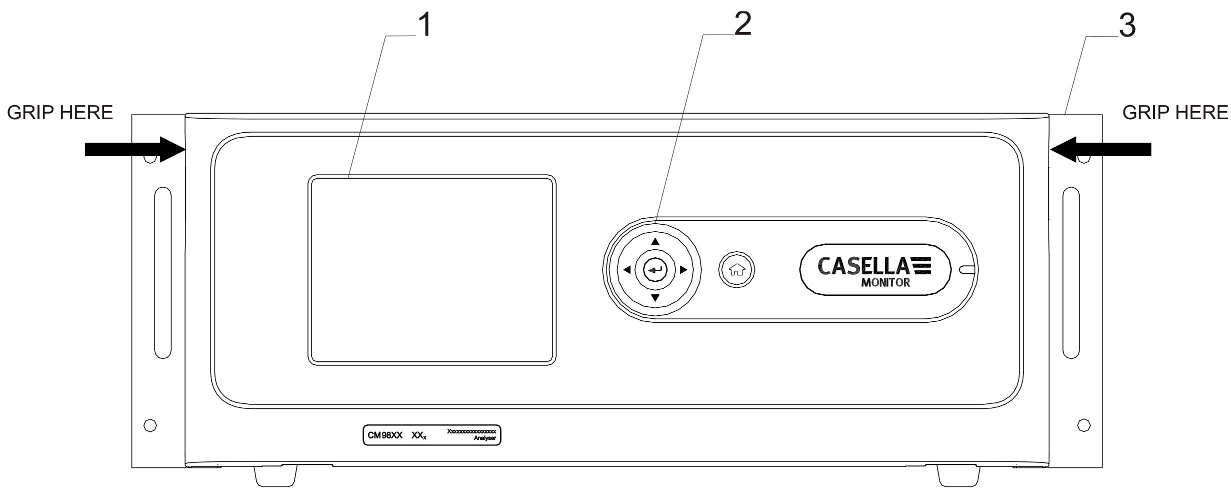
Check to make sure your instrument arrived undamaged. If you find damage, report it as described in the section “*Claims for Damaged Shipments and Shipping Discrepancies*” in the *CM2010 Operation Manual*.

Analysers are shipped ready to power on. Occasionally, however, rough handling during shipment causes dislodged PC boards, disconnected cables, or incorrectly positioned switches. Verify that your instrument is in operating condition by performing the following procedure.

Remove the Top Cover

Grip the front top corners of the front panel and pull forward. The panel pops loose and pivots forward. See Figure 1-1. The top cover retaining hardware is then visible as shown in Figure 2. Use a screw-driver, coin, or your fingers to turn the two retainers 90 degrees. When the retainers are loosened, slide the cover backward about 4 inches and lift the top cover straight up.

Figure 1-1 Opening the front panel



Service Switch

Opening the front panel allows a view of the secondary panel where the master AC power ON/OFF switch is located (as shown in Figure 1-2).

Figure 1-2 The secondary panel

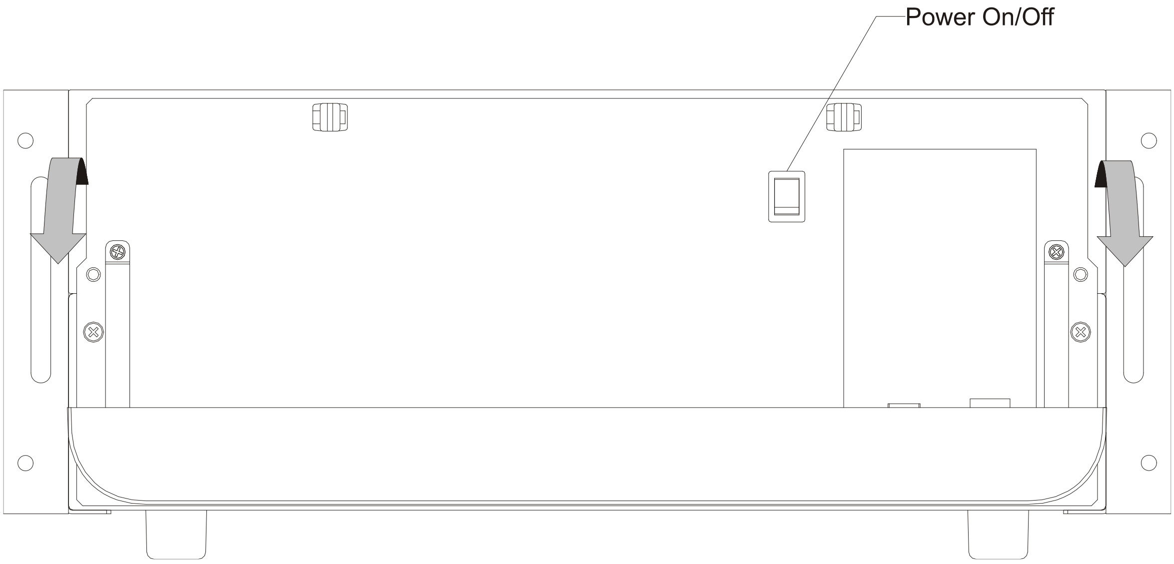
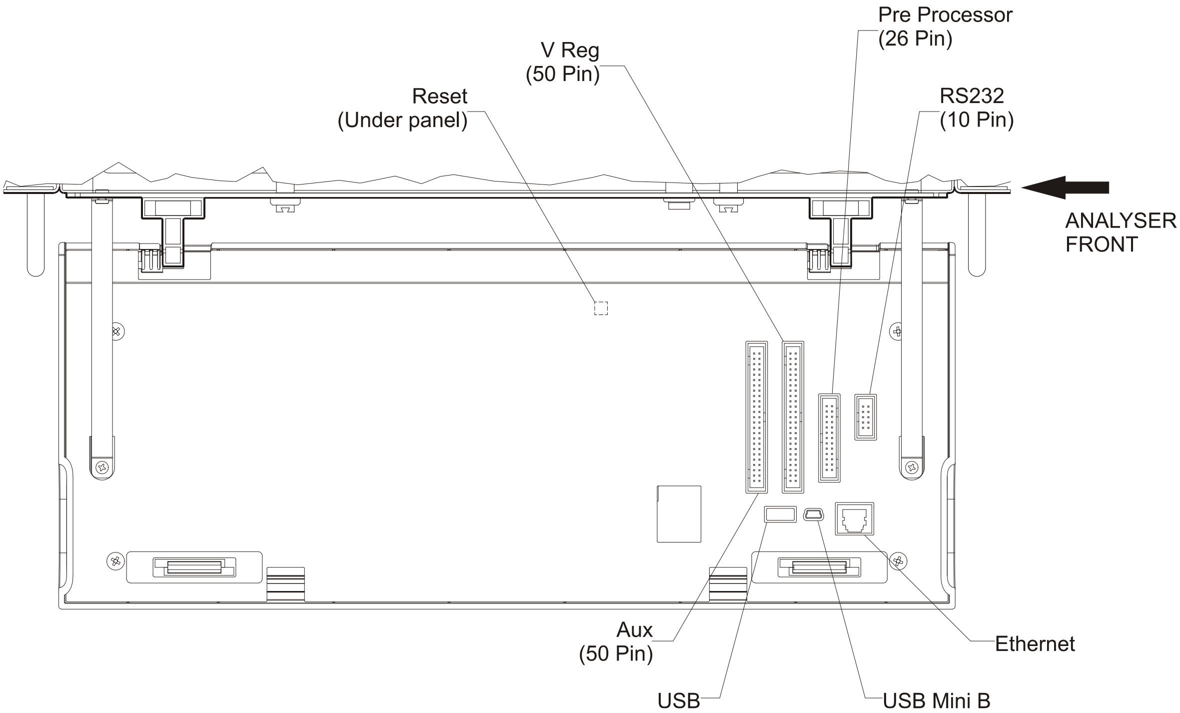


Figure 1-3 shows the connectors and the reset button on rear of the instrument's front panel with the front panel in the open position.

Figure 1-3 Rear of the front panel



Inspect the Components

Verify that the components have not become damaged in shipping. If any PC boards are dislodged or cables disconnected, follow the instructions below.

Reinsert Dislodged Boards

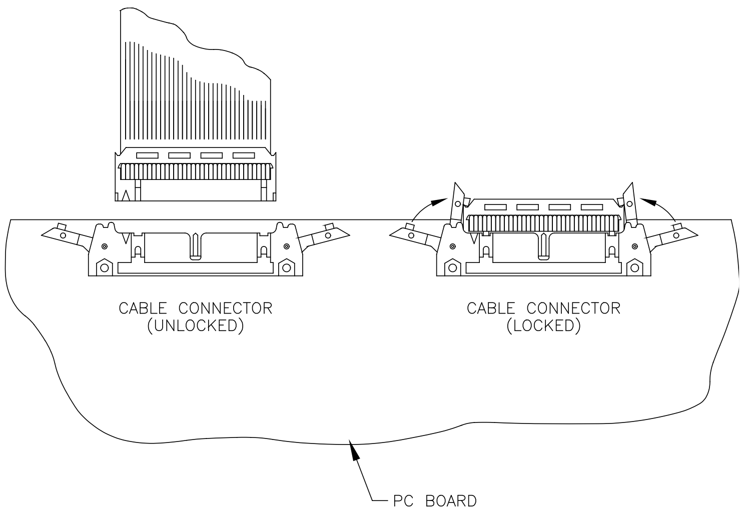
The bottom edge of the boards must be held in place by the guides. The top of the boards must be attached to the metal bulkheads by the plastic or metal studs with spring tips.

Cable Connections

Caution
The connections on the ribbon cables are polarised. Make sure you connect the cables to the correct sockets. DO NOT force the connectors into the sockets.

The cable connectors and the board connectors must be matched securely in place for correct connection. The red indicator on each cable must be positioned at the arrowhead mark on the board connector. Make the connection by pressing the cable connector into the mating connector until a click is heard. Then, fold the retainers inward to secure the connection (see Figure 1-4).

Figure 1-4 Cable connections



2 Theory of Operation

Ozone exhibits strong absorption in the ultraviolet spectrum around 250 nanometers (nm). The CM2010 ozone analyser exploits this absorption feature to accurately measure ozone concentrations to less than 0.5 ppb. A stream-switched, single-beam photometer serves as the basis for the CM2010.

A mercury vapour lamp is used as the source and a solar blind vacuum photodiode is used as the detector. A glass tube serves as the absorption cell. During the reference cycle of the stream switching process, air is drawn into the photometer through a scrubber, which removes all ozone, so that the basal light intensity (I_0) is determined. The valve is then switched to allow ambient air to fill the cell. During this measurement cycle the light intensity (I) is determined. The Beer/Lambert Law gives the relationship between these measurements and the ozone concentration as follows:

$$(O_3)_{OUT} = \left(\frac{-1}{al} \ln\frac{I}{I_o}\right) \left(\frac{T}{273}\right) \left(\frac{760}{P}\right) \left(\frac{10^6}{L}\right)$$

Equation 2-1

where:

$[O_3]_{OUT}$ = O_3 concentration, ppm

a = absorption coefficient of O_3 at 254 nm = 308 $atm^{-1}cm^{-1}$ at 0 °C and 760 torr (760 torr = 101 kPa)

l = optical path length, cm

T = sample temperature, K

P = sample pressure, torr

L = correction factor for O_3 losses.

A number of compounds absorb at 254 nm, the predominant wavelength emitted by the UV lamp. Such compounds include aromatics, SO_2, and others. The scrubber selectively removes O_3 but passes the interfering compounds. Thus, the intensity ratio described in the previous paragraph is a function of only ozone absorption.

The microprocessor and electronics of the CM2010 control, measure, and correct for all the major external variables to ensure stable and reliable operation. For example, the absorption coefficient is temperature and pressure sensitive. The CM2010 contains temperature and pressure sensors which are used to correct the coefficient for prevailing conditions. This ensures that an CM2010 analyser calibrated under one set of conditions will still be accurate when operated in another.

The CM2010 analyser has no internal mechanical adjustments. The microprocessor monitors all critical variables and makes the necessary adjustments. The algorithms have been designed so that no adjustments affect calibration.

The CM20xx analyser family uses the advanced digital Kalman filter. This filter provides the best possible compromise between response time and noise reduction for the type of signal and noise present in ambient air analysers and their applications.

The Casella Monitor implementation of this filter enhances the analyser's measurement method by making the time constant variable, depending on the change rate of the measured value. If the signal rate is changing rapidly, the instrument is allowed to respond quickly. When the signal is steady, a long integration time is used to reduce noise. The system continuously analyzes the signal and uses the appropriate filtering time. Casella Monitor analysers have passed USEPA equivalency testing using this advanced signal filtering method.

2.1 Instrument Description

The instrument is designed in a modular format consisting of a power/microprocessor module and a sensor module. The power/microprocessor module contains the power supply, voltage regulators, and the system microprocessor. The sensor module contains all components necessary to measure the pollutant gas. See Figure 2-1 for the functional relationship of components and Figure 2-2 for the location of major components.

Figure 2-1 System block diagram

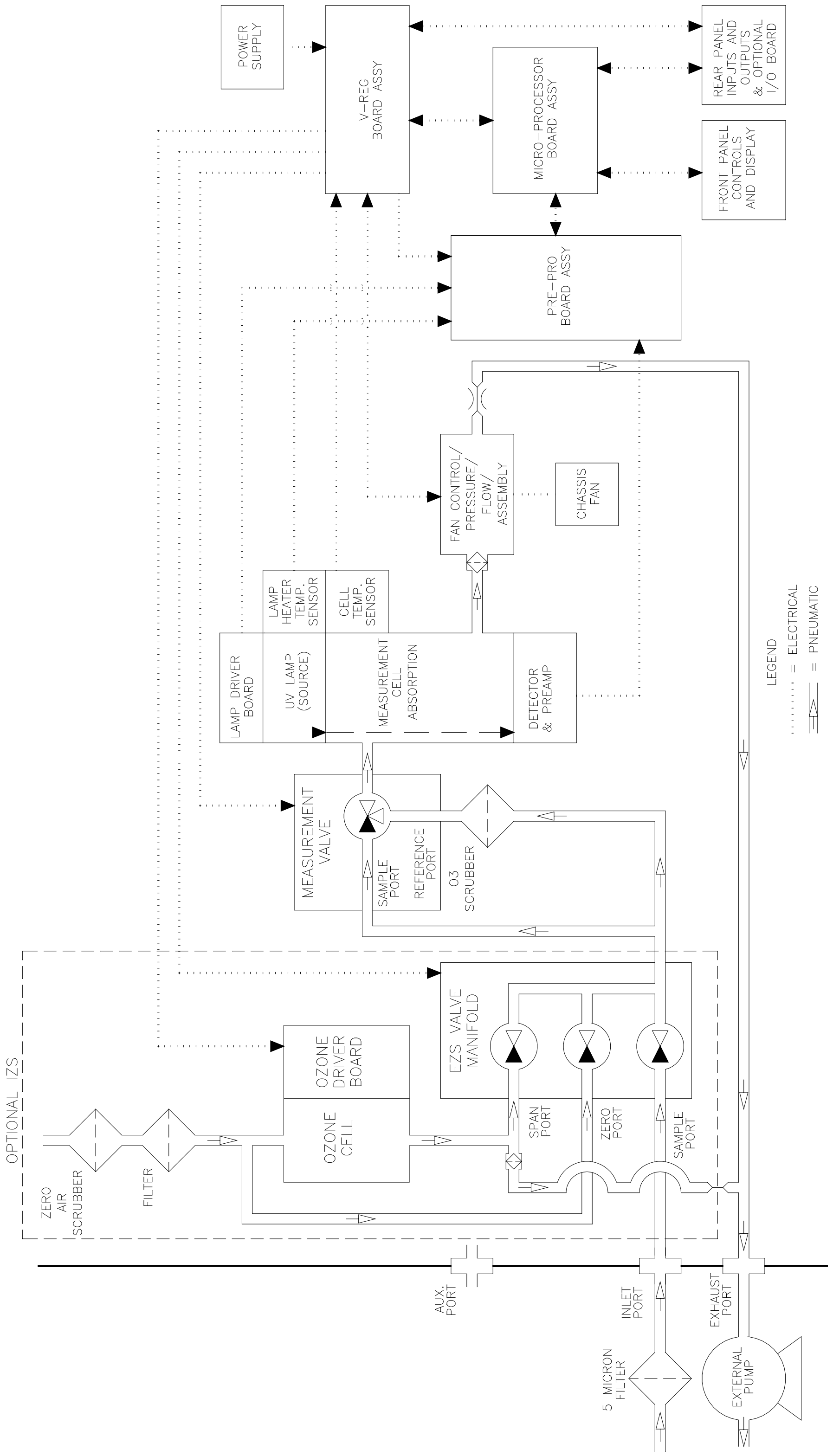
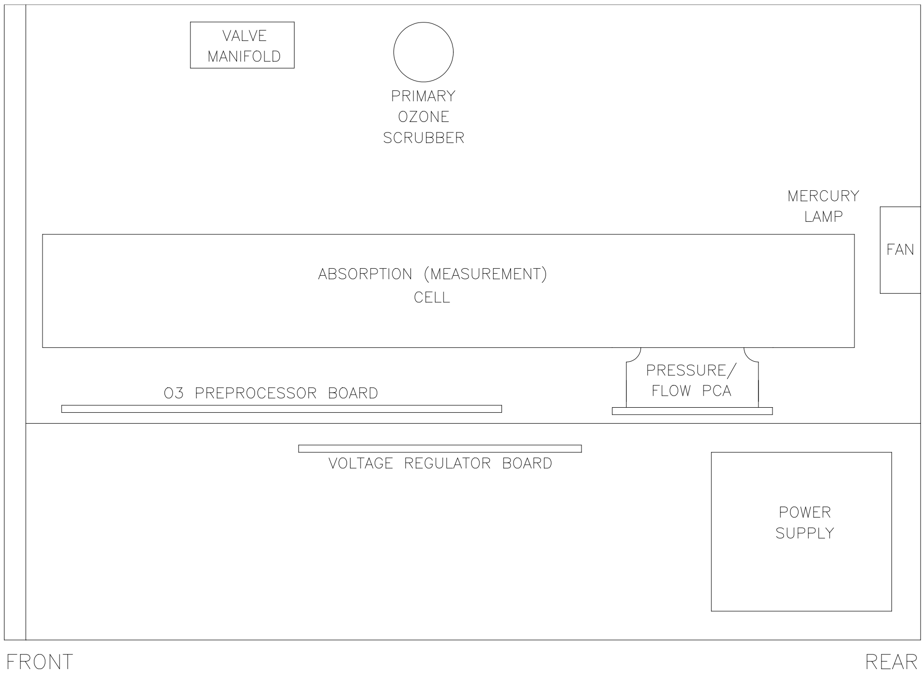


Figure 2-2 Major components



Power/Microprocessor Module

The power/microprocessor module can be described in three sections: the power supply, the voltage regulator, and the microprocessor.

Power Supply

The power supply is a self-contained unit housed in a steel case. It is designed to meet UL, VDE, CSA, and other regulatory requirements. It converts a supply in the range 99 V to 264 V 50/60 Hz to 12 VDC power for distribution within the analyser. The power supply also provides a 250 ms power extension in the event of power failure to allow the computer to store data before the power failure can affect it.

Voltage Regulator

The voltage regulator board regulates and distributes the different voltages needed throughout the system: 12 VDC to +5 VDC for the digital circuitry and 12 VDC to ±10 V for analog circuitry.

An additional +15 VDC supply is present to power the microprocessor display supplies and analog output circuits. The voltage regulator also provides a 300 ms power extension in the event of power failure to allow the computer to store data before the power failure can affect it.

Microprocessor

The microprocessor board contains a clock/calendar and an onboard microprocessor. The microprocessor board is the control centre for input and output apparatus such as the 320 × 240 pixel colour liquid crystal display (LCD), the control keys, and the connection ports on the rear panel. The 50-pin I/O connector input accepts control lines from the rear panel and sends status and failure signals to solid-state relay drivers. Support circuitry for the liquid crystal display includes a 20 V power supply and digitally-adjusted potentiometers under software control for contrast and backlight level.

All analog voltages from the sensor assembly are digitized by the analog-to-digital (A/D) converter for microprocessor use. Digital-to-analog (D/A) conversion of three channels is used to send 0 to 20 mA analog signals to the 50-pin I/O connector.

The microprocessor uses Flash memory to store the operating program, and battery-backed RAM for storage of critical parameters and data, saving them for more than 2 years.

<u>Firmware Up-grading</u>

Firmware upgrading may be required to support upgrades and code corrections.

Download the latest firmware from Casella Monitor. Two files are provided:

- casella.
- casella-version.

Copy both files to a blank USB memory stick (2GB max). With the analyser switched off, hinge down the front panel by griping where shown in Figure 1-1 and pulling forward. Insert the memory stick into relevant port and power-on the analyser.

Loading the new firmware takes typically less than 30 seconds. The code automatically loads and the analyser starts normally, running the new version of firmware.

Sensor Module

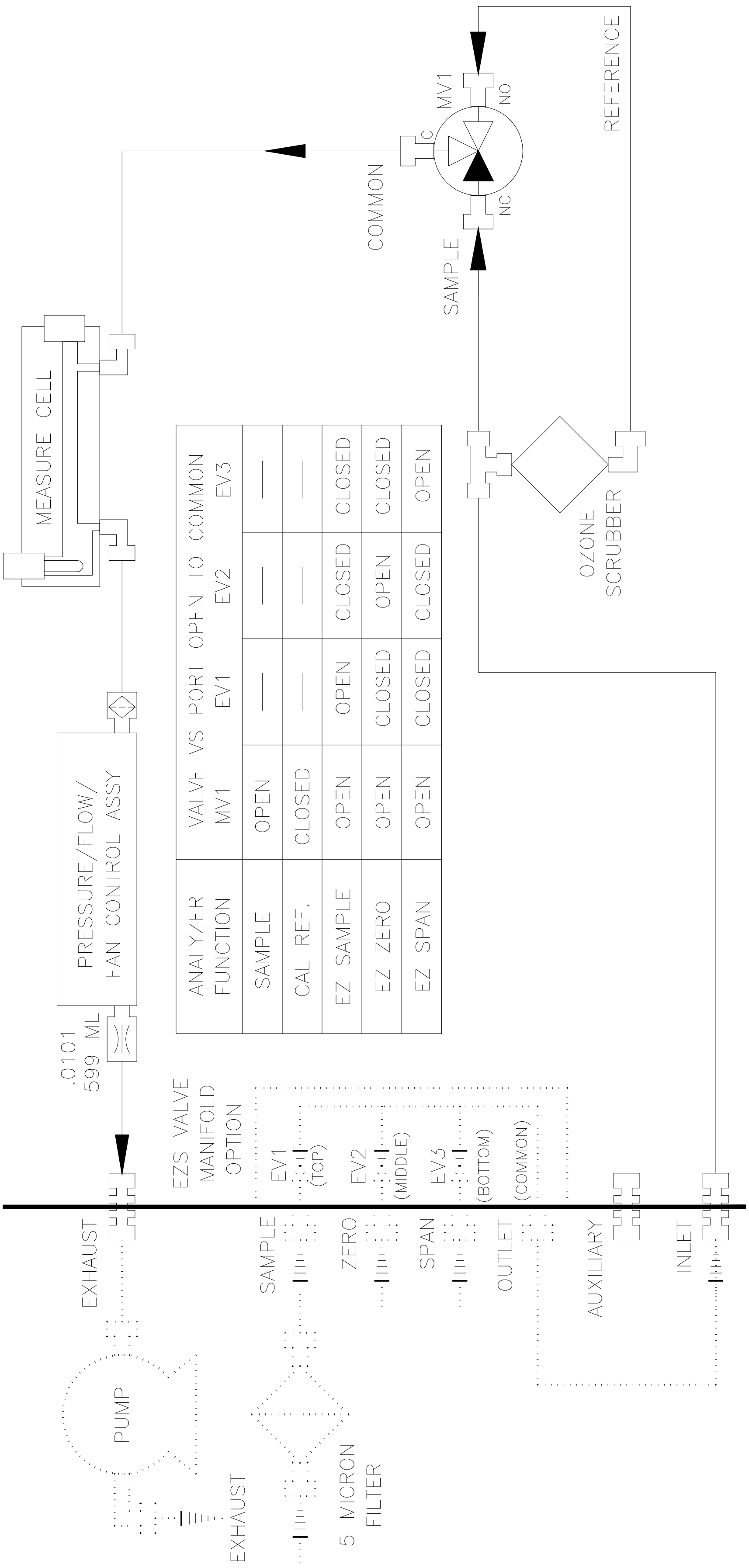
The sensor module comprises three areas of description: pneumatics, optics, and electronics.

<u>Pneumatics</u>

The pneumatic system continuously supplies particulate free sample air to the measurement cell at a constant rate, allowing the sample to be measured before exiting the analyser. The pneumatic system flow is illustrated in Figure 2-3.

The pump pulls a slight vacuum which causes sample air to be drawn into the sample inlet and through the 5 micron particulate filter.

Figure 2-3 Pneumatic diagram



ANALYZER FUNCTION	VALVE VS PORT OPEN TO COMMON MV1	EV1	EV2	EV3
SAMPLE	OPEN	—	—	—
CAL REF.	CLOSED	—	—	—
EZ SAMPLE	OPEN	OPEN	CLOSED	CLOSED
EZ ZERO	OPEN	CLOSED	OPEN	CLOSED
EZ SPAN	OPEN	CLOSED	CLOSED	OPEN

- **Ozone Scrubber**. The ozone scrubber uses manganese dioxide coated screens to remove only ozone from the air stream. As such, interferences are sampled on both cycles and their effect is cancelled, making the instrument selective for O_3.

  The copper screens in the scrubber have been carefully coated with manganese dioxide (MnO_2). The performance of the selective scrubber is process-sensitive and the scrubber must be manufactured under strict quality conditions to perform correctly. Incorrectly coated screens will result in unpredictable instrument performance. Use of any scrubber other than those provided by Casella Monitor is not permitted for monitoring under USEPA regulations without prior approval.

- **Flow Control Module**. The flow in the CM2010 is controlled by critical orifices in the flow control module. The flow control module monitors sample pressure and flow, heats the flow block, and powers the chassis fan.

Sample flow rate is controlled by a critical orifice in the flow block. Displayed flow through the analyser is calculated based upon flow through the orifice at a given upstream pressure. This upstream pressure is monitored by a calibrated pressure transducer, with the assumption made that the downstream side of the orifice is at less than half the pressure of the upstream side by the sample pump (this is required for the orifice to remain critical). Flow through the analyser is verified by measuring the differential (gauge) pressure between the upstream side of the orifice and ambient pressure.

Optics

- **UV Source**. The UV source is a mercury vapour lamp operated at 10 mA by a regulated power supply. The lamp temperature is controlled to approximately 50 °C to ensure stable operation.

- **Measurement Cell**. The measurement cell is a glass tube with the UV source at one end and the UV detector at the other.

- **UV Detector**. The detector is a solar blind vacuum diode sensitive only in the spectral region where O_3 absorbs

Electronics

- **Preamplifier Board**. The preamplifier (preamp) board converts the current from the UV detector to voltage and amplifies it. The microprocessor measures the light intensity during the scrubbed air cycle and during the sampling cycle. The ratio of the intensities is proportional to O_3 concentration.

- **Pre-processor PCA**. This circuit board contains the analog electronics that condition the detector signal, generate the lamp control signals, and generate all the signals required for preamp, optic, and electronic test diagnostic functions. It also contains a heater control circuit to heat the UV lamp block to 50 °C. The board also contains an EAROM which contains device identification and stored setup parameters. All circuitry adjustments are made via microprocessor controlled digital potentiometers.

- **Lamp Driver PCA**. The lamp driver contains a high voltage switching supply to start and maintain the UV lamp at a constant intensity. This board is under the control of signals from the pre-processor PCA.

- **Preamp/Pressure PCA**. The pressure/flow portion of the board contains an absolute and a gauge pressure transducer to measure cell pressure and detect sample flow. This board also powers the chassis fan and has a heater control circuit to heat the flow block.

2.2 Operation Modes

The analyser operates in a number of different measurement modes. These modes include start-up, measurement, and auto-zero modes. The following is a description of each of the operating modes.

Start-up Mode

When the instrument is initially powered on several components in the instrument are automatically configured by the microprocessor. This process can require up to 30 minutes to complete. Following is a description of the various adjustments made during the start-up routine. All adjustments are automatically performed by the microprocessor and no manual intervention is required.

Reference Adjust

Reference adjust allows the input gain of the pre-processor measurement channel to be adjusted for the proper reference voltage level (the reference voltage is proportional to the intensity of the UV lamp). The microprocessor initially adjusts the lamp-adjust potentiometer for a lamp current of 10 mA, then the input potentiometer for a reference voltage of 3.0 ±0.2 volts. After the reference voltage is set it is not adjusted again until another auto start-up routine is performed or the reference voltage goes below 1 volt or above 4 volts.

After the UV lamp has been adjusted, the reference voltage is continuously monitored to ensure it is stable during operation. If the reference voltage becomes momentarily unstable, the analyser will display REFERENCE STABILIZATION until the lamp achieves stability.

Zero Adjust

After the reference voltage is set the analyser must adjust the pre-processor to offset the electronic signal present during the zero (background) cycle. The cell is filled with zero air, then the pre-processor measure coarse zero and measure fine zero potentiometers are adjusted until the concentration voltage is just above 0.00 volts. (The concentration voltage is a signal proportional to the measurement of gas). After start-up this signal level is continuously monitored and adjusted as necessary.

Sample Measurement

The CM2010 is a stream-switched analyser. This means that the analyser is constantly switched between a background (zero) cycle and a measure cycle. These streams are switched approximately every 10 seconds. The difference in detected signal between the two cycles is proportional to the measurement concentration. The current operational mode is displayed on the analyser main screen: SAMPLE FILL/MEASURE or BACKGROUND FILL/MEASURE.

Quick Start Routine

If the analyser power is removed for less than two minutes, the full start-up routine is replaced by a quick-up routine. The analyser is returned to its last known operating parameters and normal operation is restored. This allows the analyser to rapidly return to measurement mode and keeps data loss to a minimum. If power is lost for more than two minutes, a full auto-restart is performed.

3 Maintenance and Troubleshooting

3.1 Periodic Maintenance

The following outlines a periodic maintenance schedule for the CM2010 analyser. This schedule is based on experience under normal operating conditions, and may need to be modified to suit specific operating conditions.

Interval[1]	Item	Procedure
Weekly	Inlet Particulate Filter	Check/Replace
	Fan Filter	Check/Clean
1 year	Pneumatics	Clean
	Sintered Filter	Replace
Weekly	UV Lamp	Check/Replace
	Ozone Scrubber	Check/Replace
	Leak Check	Perform

Check Particulate Filter

The inlet filter prevents particulates from entering the pneumatic components of the CM2010. Contamination of the filter can result in degraded performance of the instrument, including slow response time, erroneous readings, temperature drift and various other problems.

Several factors affect the filter replacement schedule. In the springtime, for example, the filter might accumulate pollens and dust. Man-made environmental changes such as construction dust might indicate more frequent change, or a climate where dry, dusty conditions are normal might dictate more frequent filter replacement than climates with few natural pollutants.

Determining the schedule for changing the filter is best developed by monitoring the filter at weekly intervals for the first few months, then adapting the schedule to fit the specific site.

Clean Fan Filter

The instrument's fan filter is located on the rear of the analyser. If this filter becomes contaminated with dust and dirt, it may affect the cooling capacity of the analyser. The fan screen should be cleaned by removing it from the analyser and blowing it out with compressed air, or by cleaning it with mild soapy water and air drying.

[1] Suggested intervals for normal operation and actual intervals will vary, depending upon application. The user can refer to this table as a guideline, but should develop a maintenance schedule to suit their specific requirements.

Pneumatic Cleaning

Cleaning the Cell Tube

Cleaning the cell tube requires removal of the glass tube from the two end blocks.

WARNING:
Apply minimal pressure while installing or removing the tube, because it may fracture and cause serious injury to the operator.

1. Loosen the retaining nut at the end of the tube. Slide the glass tube toward the front of the instrument. Rotating the tube and using both hands will help.

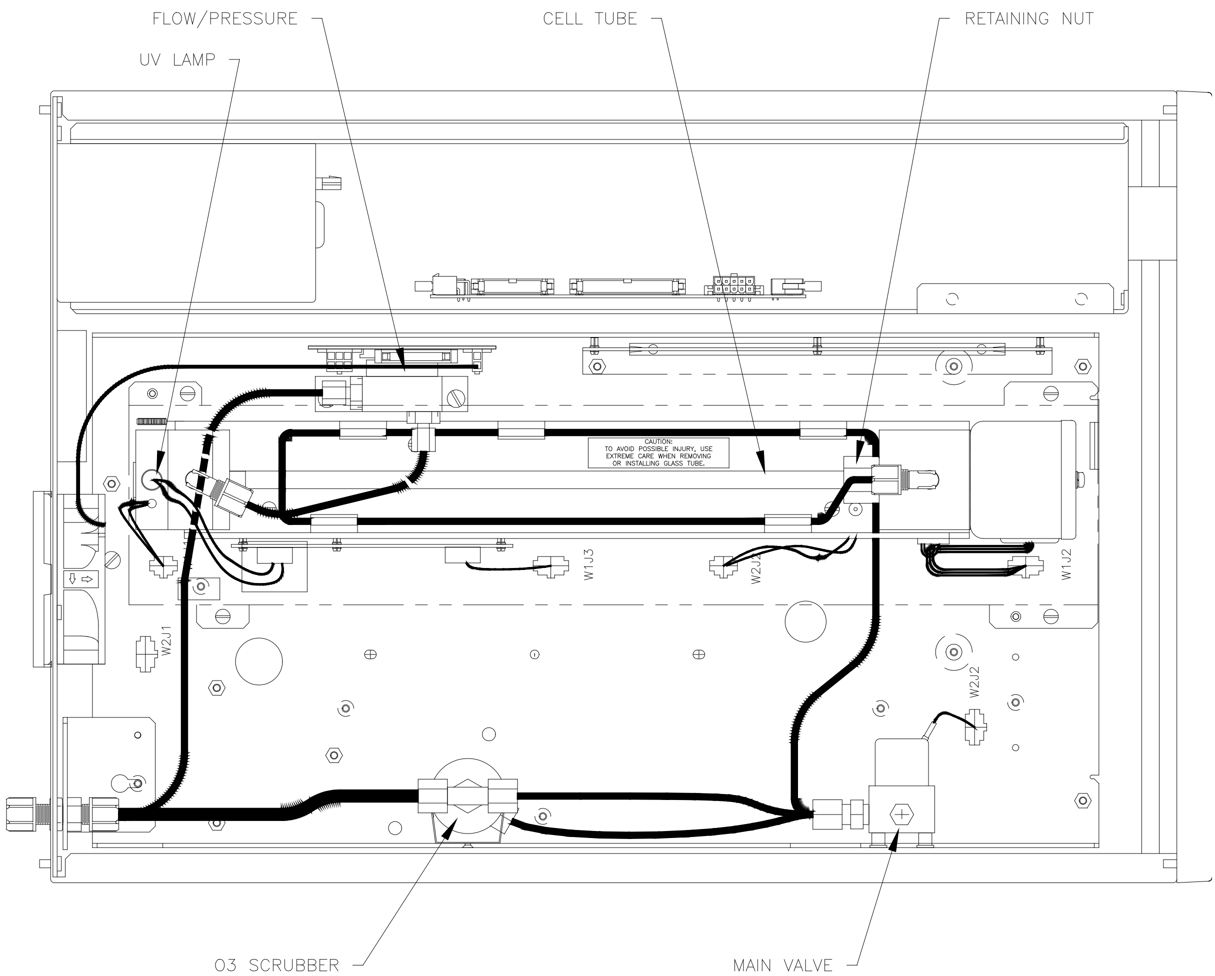
2. Inspect the tube for any particulate matter deposited on the inner walls of the tube. If any residue is detected, the entire pneumatic system should be cleaned. Do not clean the ozone scrubber.

3. Clean the glass tube by swabbing with clean, soapy water in both directions. Rinse in deionized water, then in isopropyl alcohol. Dry in air. Examine by looking down bore towards a light source. No lint, grease, or particulate matter should be present.

4. Replace the clean, dry tube in the blocks by first placing the tube in the front block and sliding it into the rear block. The O-rings on either end of the Rx cell mounting may also be replaced. Tighten the retaining nut.

5. Perform the leak test.

Figure 3-1 Routine maintenance components



Cleaning the Lines

The pneumatic lines (sample and exhaust) may be cleaned by removing and washing with a methanol cotton swab pushed through and dried by blowing with zero air or dry nitrogen. Do not clean the scrubber.

Note: After tube or cell cleaning the analyser should be allowed to sample O_3 at approximately 0.400 ppm overnight to recondition the pneumatics prior to calibration.

Sintered Filter Replacement

The sintered filter is used as a final filter to prevent contamination and blockage of the sample orifice. If the filter becomes plugged it will result in loss of sample flow through the analyser. Typically replacement of the sintered filter alone will be sufficient to maintain operation, but occasionally the orifices should be checked and cleaned to ensure proper operation.

Required Equipment: Orifice/filter removal tool (P/N 98000190)

1. Turn off the pump.

2. Disconnect the pneumatic and electrical connections from the flow control block and remove the block from the analyser. Refer to Figure 3-2 below.

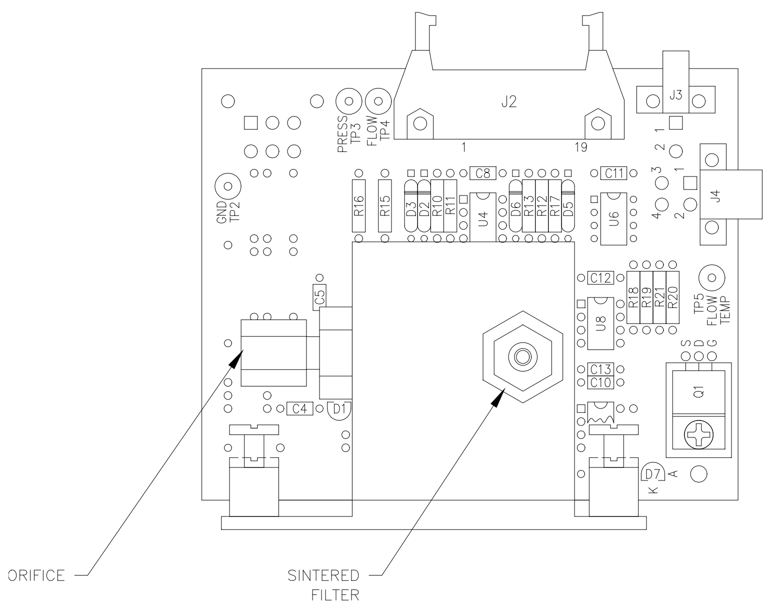
3. The sintered filter is located in the inlet fitting of the flow block. Remove this fitting and replace the filter (be sure to use a new O-ring). Reinstall the fitting into the block, ensuring the O-ring is in place around the base of the fitting.

4. The sample orifice is located in the outlet fitting of the flow block. If desired, remove this fitting and replace the orifice (be sure to use a new O-ring). Reinstall the fitting into the block, ensuring the O-ring is in place around the base of the fitting.

5. Reinstall the flow block into the analyser and reconnect the pneumatic and electrical connections.

6. Turn on the pump.

Figure 3-2 Sintered filter replacement



UV Lamp Check

The UV lamp must be of sufficient intensity to ensure proper operation of the analyser. A weak UV lamp will cause the analyser output to become noisy. If the signal becomes extremely weak, measurement will stop completely.

The intensity of the UV lamp is indicated by the gain required to maintain a sufficient signal. This gain can be viewed as the input potentiometer setting in the PRE-PROCESSOR POTS MENU. As the intensity of the UV lamp decreases, the setting of the input potentiometer will increase.

The decrease in lamp intensity is typically very slow, but since the reference voltage is usually only adjusted during a start-up cycle; there will sometimes be a dramatic increase in the Input potentiometer setting. As a routine maintenance procedure the operator should maintain a log and record the input pot setting on a routine basis. As the input potentiometer setting approaches 100 (the maximum available gain setting), replacement of the lamp should be considered.

UV Lamp Replacement

1. Turn the analyser off.
2. Remove the analyser cover and the internal reaction cell cover.
3. Remove the screw securing the green ground wire to the UV lamp block.
4. Loosen the thumb screw securing the UV lamp and slide the lamp out of the block.
5. Install the new UV lamp in reverse order of the above steps. Be sure to insert the lamp completely in the block to achieve maximum signal strength.

Ozone Scrubber

The performance of the ozone scrubber is critical to the CM2010. Although the ozone scrubber will theoretically last forever if exposed to only O_3 and air, exposure to other elements in the atmosphere will adversely affect the life span of the scrubber. A weak or failed scrubber can result in noisy measurement, frequently caused by excessively high gain.

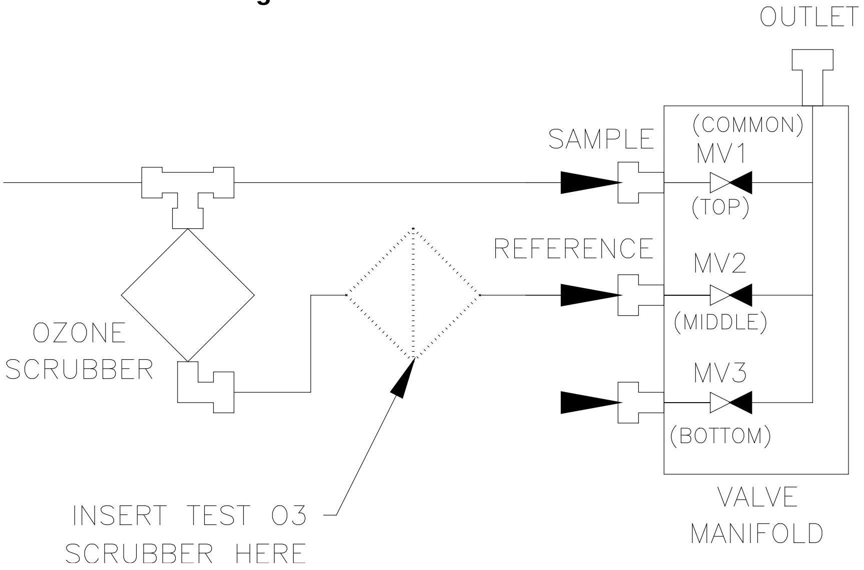
The quickest indicator of ozone scrubber efficiency is the instrument gain of the analyser. (This is calculated automatically by the analyser every time it is manually calibrated.) As scrubber efficiency decreases, instrument gain must increase to compensate for it. Because this number is, however, affected by factors such as atmospheric pressure and cell cleanliness, it is only an indicator, not a true test of scrubber efficiency. The operator should maintain a log of the instrument gain at each calibration. Any time this number increases by more than 15 % (from a known good calibration point), scrubber efficiency should be checked.

Ozone Scrubber Test

Required Equipment: O_3 source Test O_3 scrubber

1. Connect a source of span gas (approximately 0.400 ppm) to the sample inlet of the analyser. Allow the analyser response to stabilize then record the response of the analyser.
2. Connect the test scrubber in line after the primary O_3 scrubber and before the main valve. This will remove any O_3 passed by the primary scrubber. Allow the analyser response to stabilize, then record the response.
3. Compare the two readings. The second reading recorded should not exceed the first by more than 10 %. If it does, the scrubber should be replaced.

Figure 3-3 Ozone scrubber test



Leak Check

The leak check ensures the integrity of the pneumatic system, and should be performed annually or after any maintenance on the pneumatic system. To leak check the CM2010, perform the following:

Note: This leak check procedure requires that the vacuum capacity of the pump be known and converted to an equivalent atmospheric pressure. This can be obtained by connecting a vacuum gauge through a tee to the pump inlet.

1. Disconnect the sample inlet. Leave the exhaust port connected to the pump.
2. Turn off the pump and allow to settle for 2 minutes. Select the INSTRUMENT STATUS menu and record the GAS PRESSURE reading as the current ambient pressure.
3. Plug the sample inlet port.
4. Turn on the pump and allow it to operate for 5 minutes to evacuate the pneumatics.
5. Select the INSTRUMENT STATUS menu and monitor the GAS FLOW and GAS PRESSURE readings. After 5 minutes the GAS FLOW should indicate 0.00 SLPM and the GAS PRESSURE should be equal the vacuum capacity of the pump (see following conversion) ±15 torr (2 kPa).

   Note: To convert vacuum capacity to equivalent atmospheric pressure perform the following calculation:

   Current ambient pressure (torr) – (Vacuum (“Hg) × 25.32)

   or

   Current ambient pressure (kPa) – Vacuum (kPa)

6. Unplug the sample inlet and reconnect the sample line.

CAUTION:
Do not use pressure to isolate leaks. Pressure in excess of 5 psi (35 kPa) will damage the pressure transducers.

3.2 Replaceable Parts

CM2010 Analyser Spare Parts Requirements		
Description	**Part Number**	**Level**
O-ring, reaction cell tube (2 required)	25000430-204	1
O-ring, orifice and filter	25000447-007	1
Filter element, 5 micron, consumable (50 each)	98000098-1	1
Filter, sintered	98000181-1	1
Scrubber assembly, ozone	881-025001	2
Lamp assembly, ultraviolet (ozone measuring)	98100011	2
Fitting, reducing ferrule	036-120060	3
Nut, Kynar	036-13040	3
Ferrule, 1/8 inch tubing (main valve)	28001309-1	3
Nut, 1/8 inch tubing (main valve)	28001309-2	3
Extraction tool, minifit connectors	29000141-2	3
Tube, reaction cell	881-050900	3
PCA, Voltage Regulator	98000056-SP	3
Orifice, 10 mil	98000180-09	3
Extraction tool, filter and orifice	98000190	3
Service kit, pump	98000242	3
Power Supply. 12V, 250 Watts, With Fan.	98000061-SP	3
PCA, Pre-processor	98100021-SP	3
PCA, Lamp Driver	98100031-2SP	3
PCA, Preamplifier/Detector	98100039-SP	3
Flow control assembly	98107012-1SP	3
Valve manifold, main	98107019-1	3
Heater/thermistor assembly	98300061-SP	3
Evolution Series Front Panel S/A Spare	200002A	3

Notes:

- **Level 1**: General maintenance supplies and expendables such as filters, O-rings, lamps, and so on.
- **Level 2**: Critical items that are known from experience to have a higher failure rate, such as pumps, heaters, converters, valves, and circuit boards.
- **Level 3**: Other miscellaneous items not included in Level 1 or 2. This level includes other spare parts that are not expected to fail over a given time frame.

CM2010 Analyser Spare Parts Requirements Options and Accessories	
Description	**Part Number**
Pump, external, 115V/60 Hz, 4 slpm at 20 inches Hg	884-017300
Pump, external, 100V/50 Hz, 4 slpm at 20 inches Hg	884-017301
Pump, external, 230V/50 Hz, 4 slpm at 20 inches Hg	884-017302
Pump, external, 110V/50 Hz, 4 slpm at 20 inches Hg	884-017303
Rack mount kit with slides	98000036-2
Filter, particulate, sample inlet, 5 micron	98000210-1
50-pin connector and shell kit	98000235-1
CM2010 Operation and Service Manuals	201006A
Installation kit, internal zero/span	98107035-SP
Valve manifold kit, external zero/span (EZS)	98000087
Scrubber, charcoal	98415105-1

Expected Life Span of Consumables

Component	Minimum	Typical
UV lamp (98100011)	6 months	1 year
O3 scrubber/filter (881-025001)	6 months	1 year

3.3 Troubleshooting

DC Power Supply Voltages

Before consulting the troubleshooting section, verify that the DC power supply voltages are present and within the specifications given for each printed circuit board listed in the following table. Circuit board illustrations, indicating test points and other component locations, immediately follow the troubleshooting guide.

Troubleshooting Voltage Table				
PCB	**Supply**	**DVM(–)**	**DVM(+)**	**Response**
Microprocessor	+20 V –10 V –20 V	TP8 TP8 TP8	TP7 TP11 TP12	+20 V ±0.5 V -10 V ±0.5 V –20 V ±0.5 V
Voltage Reg.	+12 V +10 V -–10 V +5 V	TP7 (agnd) TP7 TP7 TP7	TP9 TP8 TP6 TP4	+12 V ±0.5 V +10 V ±0.5 V –10 V ±0.5 V +5 V ±0.25 V
Flow/Pressure	+10 V –10 V	TP2(agnd) TP2	J1-4 J1-5	+10 V ±0.5 V –10 V ±0.5 V
Pre-processor	+12 V +5 V +10 V –10 V	TP2(agnd) TP2 TP2 TP2	J3-1,6 J3-3 J3-4 J3-5	+12 V ±0.5 V +5 V ±0.25 V +10 V ±0.5 V –10 V ±0.5 V
Lamp Driver	+12 V	TP1 (agnd)	TP5	+12 V ±0.5 V

Troubleshooting the CM2010 Analyser

Because of the sophisticated design of the CM2010 analyser, a significant amount of information about the condition of the system is available on the front panel display. You can therefore troubleshoot an operating instrument without opening the front cover.

The most useful menus in terms of troubleshooting are:

PREPROCESSOR POTS MENU

VALVE TEST MENU

EVENT LOG

INSTRUMENT STATUS

SYSTEM TEMPERATURES

SYSTEM FAULTS.

These menus provide information that may indicate a failure or an operational problem. If instrument performance appears to have changed dramatically, the component that is causing the problem can possibly be determined, thereby speeding up the corrective process. It may assist the operator to periodically check and record these parameters to establish an operational history of the analyser. In addition, information from this section may be requested by Casella Monitor service support personnel when assistance is required.

Pre-processor Pots Screen

The PREPROCESSOR POTS screen displays the potentiometer settings associated with several components and variables on the pre-processor board. Figure 3-4 shows a typical test screen for an instrument that is operating normally. The values of the potentiometer settings are somewhat arbitrary, so differences in the examples shown here and the values displayed on an operating instrument should not be construed as a definite indicator of a problem. Potentiometer settings of 99 and 0, however, represent the extreme limits of the potentiometer range and may be reason to suspect a problem. The exception is TEST MEASURE, which is zero unless changed by an operator.

Figure 3-4 Pre-processor Pots and ranges

PREPROCESSOR POTS	
MEASURE COARSE ZERO	: 62 (10 – 90)
MEASURE FINE ZERO	: 42 (0 – 99)
INPUT	: 68 (10 – 90)
TEST MEASURE	: 0
LAMP ADJUST	: 58 (40 – 80)
REF. VOLTAGE	1 – 4 VOLTS
O3	0 – 20
CONC. VOLTAGE	0.0 – 4.5 VOLTS
LAMP CURRENT	9.5 – 10.5 MA

Valve Test Menu

The VALVE TEST MENU displays the current status of each valve in the instrument. This menu can be particularly useful in correcting flow problems in the machine. The valves can be opened and closed from this menu, allowing the operator to determine whether valves are operating correctly. Valve sequencing must be ON in order for correct gas measurement to be accomplished.

Refer to the *CM2010 Operation Manual* for a key to the valve names used in the menu.

Figure 3-5 Valve Test Menu

VALVE TEST MENU		
INT. VALVE #1	:	OPEN
INT. VALVE #2	:	CLOSED
INT. VALVE #3	:	CLOSED
AUX. VALVE #1	:	CLOSED
EXT. MEASURE	:	OPEN
EXT. ZERO GAS	:	CLOSED
EXT. SPAN GAS	:	CLOSED
VALVE SEQUENCING	:	ON

Event Log

Upon noting a possible operational problem, examine the EVENT LOG menu to determine whether the microprocessor is reporting a system failure or problem. If the EVENT LOG indicates an error, it will also provide information as to the portion or component of the instrument which is at fault.

Event Log Messages		
Message	**Description**	**Action**
INTERNAL O/S ERROR #1	Operating system does not have enough memory to run.	System software or hardware error. Call Casella Monitor Customer Service for instructions.
INTERNAL O/S ERROR #2	No task defined in O/S.	
INTERNAL O/S ERROR #3	Invalid partition size in O/S.	
INTERNAL O/S ERROR #4	Invalid queue size in O/S.	
INTERNAL O/S ERROR #5	Memory corruption in O/S.	
INTERNAL O/S ERROR #6	Task overwritten by another task.	
INTERNAL O/S ERROR #7	Integer divide by zero has occurred.	
INTERNAL O/S ERROR #8	Single step interrupt has been accessed.	
INTERNAL O/S ERROR #9	Breakpoint interrupt has been accessed.	
INTERNAL O/S ERROR #10	Integer overflow has occurred.	
INTERNAL O/S ERROR #11	An array bounds error has occurred.	
INTERNAL O/S ERROR #12	CPU tried to run an undefined instruction.	
INTERNAL O/S ERROR #13	CPU has run the escape instruction.	
INVALID OP IN TASK #X	Task #X tried to perform an illegal point operation.	
ZERO DIVIDE IN TASK #X	Task #X tried to divide a floating point number by 0.0.	
UNDERFLOW IN TASK #X	Task #X encountered number <8.43E-37.	
OVERFLOW IN TASK #X	Task #X encountered number 3.37E+38.	
FLOAT ERROR TASK #X	Task #X encountered multiple floating point math errors.	
RAM CHECKSUM FAILURE	Checksum of memory at power down differs from checksum at power up.	Battery failure or system software error. If error persists, call Casella Monitor Customer Service for instructions.
EAROM X DATA ERROR Y	EAROM designated "X" detected error at location "Y."	Check Pressure PCA cable connections and Pressure PCA.

Event Log Messages		
Message	**Description**	**Action**
LCD DISPLAY BUSY	LCD constantly busy indicates hardware failure in display.	Check display cable connection, Display PCA, and Microprocessor PCA.
A/D CONVERSION ERROR	A/D returned busy status	Normal at start-up. If failure persists, replace microprocessor.
SYSTEM POWER FAILURE	Power removed from system.	No action required.
SYSTEM POWER RESTORED	Power applied to system.	No action required.
INPUT POT LIMITED TO 0 OR 99	Input pot adjustment exceeds range.	Check UV lamp or clean Rx cell.
LAMP ADJUST ERROR	Lamp adjust pot reached limit before 10 mA lamp current was achieved.	Check UV lamp, Lamp Driver PCA, or Pre-processor PCA.
ZERO POT LIMITED TO 0 OR 99	Zero voltage controller reached limits before voltage reached set point.	Reset analyser, check zero air source.
REF POT LIMITED TO 0 OR 99	Reference voltage controller reached limits before reference voltage reached set point.	Check UV lamp.
ZERO FLOW	Instrument flow has gone to zero.	The pump has failed or a flow obstruction has occurred. Replace pump, or clear obstruction.
SPAN RATIO <0.75	After AZS cycle, ratio of requested span to measured span is <0.75.	Instrument span has drifted beyond acceptable limits. Recalibrate.
SPAN RATIO >1.25	After AZS cycle, ratio of requested span to measured span is >1.25.	Instrument span has drifted beyond acceptable limits. Recalibrate.
RESET DETECTION	Reset button pressed or watchdog timer caused reset.	Unless the reset was not initiated by the user, no action is required.
AZS CYCLE	AZS cycle started.	No action required.

Instrument Status

If any of the parameters displayed on the INSTRUMENT STATUS screen vary significantly from the values shown in Figure 3-6, the fault or operational problem is probably related. This is also true if one of the parameters is demonstrating a rapid change or is oscillating strongly around the desired setpoint.

Several of the parameters displayed on the INSTRUMENT STATUS screen are affected by the potentiometer settings on the PREPROCESSOR POTS screen. If a parameter is out of the normal operating range, make a note of the parameter value, proceed to the respective menu, and examine the pertinent potentiometer settings.

Figure 3-6 Instrument status ranges

```
                INSTRUMENT STATUS


      GAS FLOW         : 0.42 – 0.53   SLPM
      GAS PRESSURE     : 550 – 750     TORR
      REF. VOLTAGE     : 1.00 – 4.00   VOLTS
      CONC. VOLTAGE    : 0.00 – 4.50   VOLTS
      ANALOG SUPPLY    : 11.6 – 12.2   VOLTS
      DIGITAL SUPPLY   : 4.8 – 5.2     VOLTS
      GROUND OFFSET    : 200 – 325
      LAMP CURRENT     : 9.5 – 10.5    MA


      VERSION B1.00                    EXIT
```

System Temperatures

The SYSTEM TEMPERATURES screen provides the reaction cell temperature, the molycon temperature, the chassis temperature, the valve manifold temperature, and the thermoelectric cooler temperature used to cool the PMT. Figure 3-7 contains the nominal values which should be displayed on this screen. If any of the parameters are outside the acceptable ranges, a significant problem among these components is strongly indicated.

The SYSTEM TEMPERATURES screen provides the temperatures of the lamp, the chassis, and the flow control block. Figure 3-7 contains the nominal values which should be displayed on this screen. If any of the parameters are outside the acceptable ranges, a significant problem among these components is strongly indicated.

Figure 3-7 System temperatures and tolerances

```
               SYSTEM TEMPERATURES
      CELL TEMP.       : 20 – 60  DEG C
      LAMP TEMP.       : 45 – 55  DEG C
      CHASSIS TEMP.    : 15 – 55  DEG C
      FLOW TEMP.       : 45 – 55  DEG C
                                       EXIT
```

System Faults

The SYSTEM FAULTS display provides pass or fail indications for various parameters which are continually monitored. These parameters must be within acceptable operating ranges in order to display PASS. If FAIL is indicated, this indicates a major failure in that area.

Note: The SYSTEM FAULTS screen only indicates PASS or FAIL for the various analyser parameters, and indicates a major failure. Desired operating ranges are indicated in the INSTRUMENT STATUS and SYSTEM TEMPERATURE ranges section. If analyser readings are not within these ranges, it could indicate deterioration of certain assemblies within the analyser, or minor failures.

The following table lists the possible SYSTEM FAULTS messages which are displayed on the primary screen if a major failure occurs. If a fault message is displayed, use the troubleshooting guide to find the possible cause of the fault.

System Fault Messages	
Message	**Description/Failure Limits**
OUT OF SERVICE	Indicates the Service switch is in the OUT position. Unless the analyser is being serviced, this switch should be in the IN position.
ZERO FLOW	Indicates that the gauge pressure from the Pressure PCA is less than 20 torr (bad pump or plugged orifice) or greater than 200 torr (plugged inlet). Can also occur if the sample inlet is pressurized.
LAMP FAILURE	Indicates that the lamp current is not within the acceptable limits. In the CM2010, a fault is indicated if the lamp current is below 5 mA or above 15 mA.
REFERENCE VOLTAGE OUT OF RANGE	Indicates that the reference voltage is not within the acceptable limits. In the CM2010 a fault is indicated if the reference voltage is below 1 volt or above 4 volts.
12 VOLT SUPPLY FAILURE	Indicates that the 12 volt supply voltage is not within the acceptable limits. A fault is indicated if the 12 volt supply voltage is below 11.1 volts or above 14.3 volts.
CELL TEMPERATURE FAILURE	Indicates that the cell temperature is not within the acceptable limits. A fault is indicated if the cell temperature is below 5 °C or above 60 °C.
FLOW BLOCK TEMP	Indicates the flow block temperature is not within acceptable limits. A fault is indicated if the flow temperature is below 35 °C or above 60 °C.

Test Functions

The following lists the available diagnostic modes in the CM2010.

Optic

Not supported.

Preamp

The preamp test function generates an electronic test signal which is applied to the input of the UV detector preamp. This simulates an input from the detector and is then processed as if it were an actual signal. This test is used to verify the operation of the detector.

Electric

The electric test function generates an electronic test signal which is applied to the input of the pre-processor. This simulates an input to the pre-processor and is then processed as if it were an actual signal. This test is used to verify the operation of the pre-processor PCA reference and measure channels.

Use of Diagnostic Modes

The diagnostic modes are actuated by selecting DIAGNOSTIC MODE: OPTIC or PREAMP or ELECTRIC and adjusting the test measure potentiometer until a response (simulated concentration) is noted. Response to tests will vary depending upon individual analyser parameters. These tests are typically pass/fail. Functional problems can be isolated to a single component by logical use of the diagnostic modes.

Troubleshooting Guide

Use this troubleshooting guide to find the symptom. Then follow in order the possible causes and the fault isolation/solution procedures until the problem is discovered. Then take the action described. If you cannot identify the problem, E-mail technical support – techsupport@casellamonitor.com

System Troubleshooting Table		
Symptom	**Possible Cause**	**Fault Isolation/Solution**
1. No display/ instrument dead	AC power	1. Verify that the line cord is connected. 2. Check that the power supply fuse is not open. The fuse should be 5A (115 V) or 3A (230 V). 3. Verify that the Voltage switch is in the proper position.
2. No display	Contrast misadjusted	Set or adjust the display contract or backlight intensity. Refer to the *CM2010 Operation Manual*.
	DC power	1. Verify the cable connection from the power supply to the Vreg board. 2. Check the Vreg board for correct voltages as listed in the troubleshooting voltages table (above). If incorrect voltages are found, replace the power supply or Vreg.
	No +15 volts from Vreg PCA.	Move JP3 on the microprocessor to the +12 volt position.
	Display	Check the interface cable between the display and J6 on the Microprocessor board.
	Bad display or Microprocessor PCA.	1. Replace the front panel display. 2. Replace the Microprocessor board.
3. Zero flow	Pump failed	Replace the pump.
	Filter	Check the particulate filter. Replace if dirty or plugged.
	Pressurized Rx cell	Ensure sample and zero inlets are maintained at ambient pressure.

System Troubleshooting Table		
Symptom	**Possible Cause**	**Fault Isolation/Solution**
	Plugged orifice or SS filter	Clean or replace the orifice and SS filter.
4. Noisy or unstable readings	Leaks	A leak dilutes the sample stream and causes low span readings and noise. See Leak Check section .
	Particulate filter	Replace the particulate filter.
	Rx cell temperature	Ensure the reaction cell and analyser covers are installed.
	Scrubber filter	Check ozone scrubber. Replace the particulate
	Rx cell dirty	Clean Rx cell.
	UV lamp	Check UV lamp.
	UV detector	Replace UV detector.
5. Low span	Span setting	Adjust the span using the Calibration Procedure in Chapter 3, Calibration.
	Scrubber	Check ozone scrubber.
	Rx cell dirty	Clean Rx cell.
	UV lamp	Check UV lamp.
	No flow	See the Zero flow symptom in this table.
	Leaks	A leak dilutes the sample stream and causes low span readings and noise. See Leak Check section .
6. No response to span gas	Instrument gain	Verify the instrument gain is not set to 0.000.
	Leaks	A leak dilutes the sample stream and causes low span readings and noise. See Leak Check section .
	No flow	Check the INSTRUMENT STATUS menu and verify flow.
	Software lockup	1. Observe whether MAIN MENU on the display is blinking. 2. Verify that other menus can be selected. 3. Press the Reset button on the secondary panel. 4. Replace the Microprocessor board.
7. Zero drift	Leak	A leak dilutes the sample stream and causes low span readings and noise. See Leak Check section .
	Zero air source	Replace zero air source.
8. Unstable flow or pressure readings	Failed flow control heater	The flow temperature (SYSTEM TEMPERATURES screen) should be 50° ±5° C.
9. Instrument stuck in reference adjust	Reference voltage (INSTRUMENT STATUS screen) not at 3 volts.	Perform UV lamp check and adjustment.
	Lamp current not at 10 mA.	Replace UV lamp, Lamp Driver PCA, or Preprocessor PCA.

System Troubleshooting Table		
Symptom	**Possible Cause**	**Fault Isolation/Solution**
10. Response time not at specified value	Low flow	Check sample flow with flowmeter. It should be 0.4 to 0.6 slpm @ STP. Replace SS filter or orifice if it is not.
11. Analyser displays GAS: CO	Pre-processor ID set wrong	1. Reprogram device ID. Refer to Processor ID Entry section. 2. Replace Pre-processor

3.4 Routine Maintenance

Following is a list of routine maintenance procedures which may be required through the life of the analyser.

Recommended maintenance equipment

- Toolbox
- Oscilloscope
- Digital multimeter (DMM)
- Computer or remote data terminal and connection cable for RS232 communication
- Pressure transducer (absolute) and connection tubing, calibrated in torr
- Flowmeter (2 slpm nominal)
- Wire strippers
- Soldering iron
- Minifit extraction tool
- Orifice removal tool
- Assortment of 1/4” and 1/8” tubing and fittings
- Test zero air source
- Test span gas source
- Leak tester.

Flow/Pressure PCA Calibration

The flow/pressure PCA calibration should be performed whenever a flow or pressure reading becomes suspect or when a transducer is replaced, or can be performed as an annual maintenance item. This procedure recalibrates both the flow and the pressure transducers.

Required Equipment

- Computer or remote data terminal
- Pressure transducer (absolute); calibrated in torr.
- Flow meter, 1 slpm nominal

1. Turn off the pump.
2. Using a computer or remote data terminal, establish RS232 communications with the analyser (refer to Chapter 4, Digital Communication, for RS232 communication setup). INTERFACE MODE: should be set to COMMAND.
3. Verify communication with the following command from the terminal:

   DCOMM,???↵

   The analyser should respond with a serial character dump to the terminal.
4. Program the flow type with the following command:

   FTYPE,???,1,1,2 ↵

   The analyser should respond FLOW BLOCK PROGRAMMED.
5. Press Reset on the analyser secondary panel.
6. Disconnect the inlet tubing from the flow block and connect a calibrated pressure transducer to this inlet.
7. Allow the pressure reading to stabilize. This reading should be ambient pressure. Program this value with the following command:

   SETP1H,???,1,1,XXX↵ (where XXX is the pressure reading in torr)
8. Connect the pump to the exhaust port and turn on the pump.
9. Allow the pump to evacuate the cell and the pressure reading to stabilize. This reading should be low (typically 100 to 200 torr), and is dependent upon the capacity of the pump. Program this value with the following command:

   SETP1L,???,1,1,XXX↵ (where XXX is the pressure reading in torr)
10. Disconnect the pressure transducer from the flow control inlet and reconnect the inlet tubing.
11. Press Reset on the analyser secondary panel.

    Note: The gas pressure and gas flow readings on the INSTRUMENT STATUS menu will not update until the startup routine is complete.
12. The actual flow should now be checked by turning on the pump and connecting a flow meter to the sample inlet of the analyser. The flow should read approximately 0.5 slpm. If the flow is too low, perform the sintered filter/orifice replacement procedure. If flow is too high, there is probably a leak.

This completes the transducer calibration procedure.

Pre-processor ID Entry

Required Equipment Computer or remote data terminal

1. Using a computer or remote data terminal, establish RS232 communications with the analyser (refer to Chapter 4, Digital Communication, for RS232 communication setup). INTERFACE MODE: should be set to COMMAND.

2. Verify communication with the following command from the terminal:

   DCOMM,???↵

   The analyser should respond with a serial character dump to the terminal.

3. Program the flow type with the following command:

   DTYPE,???,1,1,2010 ↵

   The analyser should respond DEVICE TYPE SET TO 2010

4. Press Reset on the analyser secondary panel. The display should now read CM2010 O3 ANALYSER.

This completes the analyser device type programming.

4 Circuit Diagrams