Issue : 1.4

Guardian Plus
Infra-Red Gas Monitor
Operating Manual

Edinburgh Instruments Limited
2 Bain Square, Kirkton Campus
Livingston EH54 7DQ
UK
☎ 44 (0)1506-425300
Fax 44 (0)1506-425320

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Contents

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1.0 Introduction

The Guardian Plus range of single point, fixed instruments provide continuous monitoring and control of gas concentration levels. They feature comprehensive output, alarm and fault indications via the on-board microcontroller. Based on dual wavelength non-dispersive infra-red (NDIR) technology, Guardian Plus offers reliable, high performance operation with low maintenance requirements.

Main features :

- 4 digit 12.5 mm Liquid Crystal Display (LCD)
- current or voltage analogue output
- 2 independent alarm/setpoints with volt free relay contacts
- internal self test with volt free fault relay contacts
- audible and visual alarm and fault indication
- internal pump
- low flow sensor with audible and visual indication
- enclosure protection to IP54
- easily replaceable particle filter
- output options configured by user setable bitswitch

2.0 Installation

The Guardian should be mounted on a vertical surface using three M4 machine screws or No. 8 wood screws.

When choosing a site, sufficient space should be provided around the unit to allow the door to be opened and to facilitate the fitting of cables and pipework.

2.1 Mechanical Installation

Installation instructions :

1. Select a suitable position for the monitor, fit the top centre screw and hang the unit from the central keyhole.
2. Remove the terminal compartment cover to reveal the slotted fixing holes and mark suitable positions for the two securing screws.
3. Remove the monitor and drill holes for the two securing screws.
4. Hang the monitor back on the central screw and secure it through the slotted holes.

2.2 Electrical Installation

The following precautions must be observed in the installation of this equipment:

- The electrical installation should only be performed by a suitably qualified electrical engineer.
- The cable glands provide both cable restraint and sealing. They should only be used with circular cables in the range 8 to 10 mm diameter.

Check that the glands are tight after installation and that the cables are restrained.

- If the Guardian is to be connected to a standard mains outlet, a fused plug fitted with a 3A fuse should be used.
- If the Guardian is to be connected into the permanent wiring system of the building, connection should be made using suitable cable to a switched connection unit which includes a 3A fuse. The switch must be within easy reach of the equipment and should be marked as the disconnection device for the equipment. The switch must disconnect all mains power to the Guardian Plus including power to the output relay contacts.

A cable gland is provided at the left hand side of the terminal compartment for the mains supply. The mains supply voltage is switch selectable and is factory set to the value requested at the time of ordering - see rating plate on side of case. The supply voltage can be changed using the voltage selection switch located inside the Guardian Plus (see section 3.9 for further details). The switch should only be changed with the power disconnected and after changing the switch position, the rating plate must be modified to reflect the new setting.

Connections to remote equipment are made at the right hand side of the terminal compartment. Two cable glands are provided for these outputs. If mains voltages or other hazardous voltages are applied to the relays, the wiring should be separated from any low voltage wiring to the analogue output and should use a separate cable gland. Connections should not be made within the terminal compartment between the mains terminal block and other terminals. **Under no circumstances should mains voltages be applied to the analogue output as this will both damage the equipment and cause a safety hazard.**

2.3 Gas Connection

Remote sampling may be performed by connecting up to 30 metres of 5 mm bore tubing to the gas inlet. Neoprene, PVC or nylon are considered suitable tubing materials in most applications, natural rubber is not recommended due to its tendency to perish. Silicon rubber tubing is not

suitable because it readily absorbs and releases gas and therefore exhibits a ‘memory’ effect which leads to false readings. There is a small ‘memory’ effect with all plastic tubing, this is not normally a problem but for demanding applications involving longer lengths of external tubing, copper or other metal tubing should be considered. The choice of material should include consideration of the environmental conditions in which the equipment is to be operated in order to ensure compatibility.

If condensation is likely to occur in the sample line, an external water trap should be fitted and provision for emptying condensate should be made. Condensation will be a problem in situations where the sample line is cooled below the temperature of the sampling point. This may occur if the tubing is cooled by drafts, is external to the building where the sample is taken or passes through a cold area within a building.

The exhaust gas is normally vented to the local atmosphere. If safety considerations require that the gas be vented elsewhere this can be achieved by attaching 5 mm bore tubing to the outlet nozzle. Any exhaust gas system should ensure minimal back pressure as any increase in the pressure within the sensor head leads directly to a reading error (a 10 mBar back pressure causes a +1.5% of reading error - see section 5.3 for further details).

3.0 Operation

The operation of the Guardian Plus is described in terms of the outputs (display, LED indicators, analogue output, alarm and fault relays), inputs (gas sensor, flow sensor, fault detection system) and the controls (setpoint controls, setpoint buttons, test button and the options bitswitch).

The function of the equipment is controlled by the options bitswitch which allows the user to select the various output options.

3.1 Options Bitswitch

The following output options are available :

- 4-20 mA or 0-20 mA output
- linear or non-linear output
- high (normal) or low (reversed) alarm (alarm 1 & 2 controlled separately)
- normal or latched alarm (alarm 1 & 2 controlled separately)
- buzzer operation on second alarm only or on both alarms
- low flow condition treated as a fault or just used to give warning

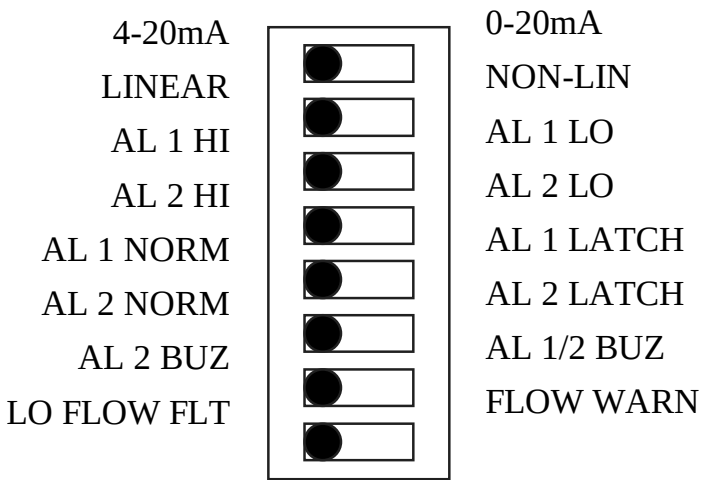
These are controlled by the options bitswitch located under the terminal compartment cover. The function of each bit in the switch is as follows :

Bit	Setting	Function
1	4-20 mA	Output scaled 4 to 20 mA for reading of zero to full scale. Minimum output = 3.0 mA, maximum output = 25.5 mA. Fault indication = 0 mA.
	0-20 mA	Output scaled 0 to 20 mA for reading of zero to full scale. Negative values reported as positive current up to 0.5 mA, maximum output = 22 mA. Fault indication = 25.5 mA.
2	LINEAR	Output linear with reading
	NON-LIN	Output follows the non-linear relationship shown in the figure on page 8 which is for a 3000 ppm instrument (other ranges can be obtained by scaling the gas axis). This facility provides compatibility with older systems which have non linear outputs. The non-linear function only operates when the 0-20 mA option is selected, the output is always linear when 4-20 mA output is selected.
3	AL 1 HI	Alarm 1 operates when the gas concentration exceeds the setpoint or if a fault is detected. The relay is energised in the non-alarming state so that it goes onto the alarming state when the equipment is depowered (fail-safe).
	AL 1 LO	Alarm 1 operates when the gas concentration falls below the setpoint or if a fault is detected. The relay is energised in the non-alarming state so that it goes into the alarming state when the equipment is depowered (fail-safe).
4	AL 2 HI	Alarm 2 operates when the gas concentration exceeds the setpoint or if a fault is detected. The relay is energised in the non-alarming state so that it goes into the alarming state when the equipment is depowered (fail-safe).
	AL 2 LO	Alarm 2 operates when the gas concentration falls below the setpoint or if a fault is detected. The relay is energised in the non-alarming state

		so that it goes into the alarming state when the equipment is depowered (fail-safe).
5	AL 1 NORM	Alarm 1 de-activates when the alarm condition no longer exists.
	AL 1 LATCH	Alarm 1 latches and must be manually reset using the Setpoint 1 push-button on the front panel.
6	AL 2 NORM	Alarm 2 de-activates when the alarm condition no longer exists.
	AL 2 LATCH	Alarm 2 latches and must be manually reset using the Setpoint 2 push-button on the front panel.
7	AL 2 BUZ	Buzzer sounds (continuous) only when alarm 2 operates or if a fault or low flow condition are detected.
	AL 1/2 BUZ	Buzzer sounds intermittently on alarm 1 and continuously on alarm 2 or if a fault or low flow condition are detected.
8	LO FLOW FLT	A low flow condition is treated as a fault and the following actions are taken : low flow LED flashed buzzer sounds continuously both alarm LEDs flash LCD read “Err” Analogue output indicates fault fault relay operates both alarm relays operate
	FLOW WARN	If a low flow condition is detected, the following actions are taken : low flow LED flashed fault relay operates buzzer sounds continuously other functions of the equipment (LCD and alarm outputs) continue to operate normally.

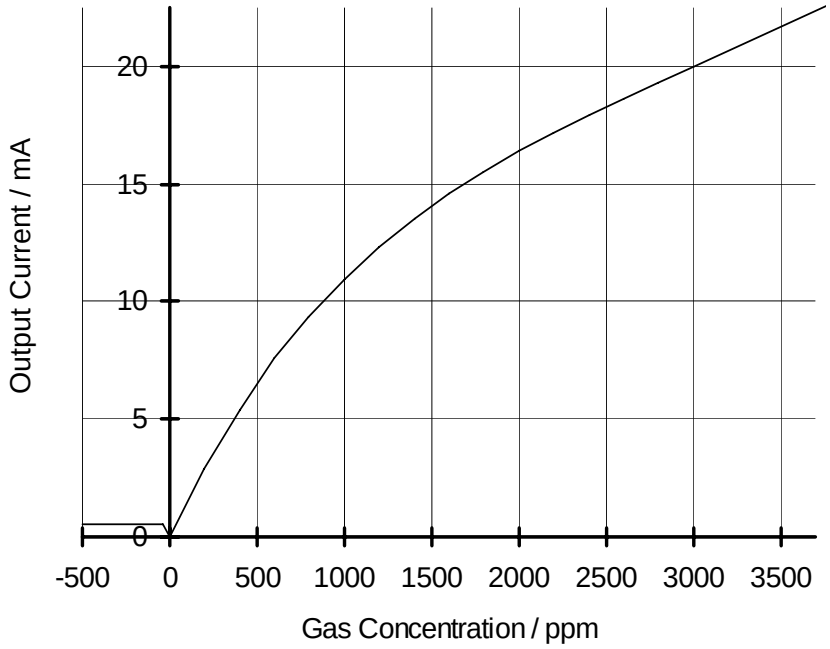
Shaded items show factory default settings

The default factory switch setting is off (left) for all bits :



The setting of the bitswitch may be changed using a small screwdriver or other suitable tool. It is not necessary to de-power the unit before changing the settings. Changes are effective immediately.

3000ppm Guardian Plus : Non-Linear Output Characteristic



3.2 Setpoint Controls

The Guardian Plus provides 2 alarms with independent setpoints, adjustable via the front panel controls. These are protected by a transparent door, secured by two plastic retaining screws at the right hand side. Unscrew these plastic screw to gain access to the front panel, re-secure the transparent door after making any adjustment to ensure that the front panel controls are properly protected.

The setpoint level can be displayed by pressing the push-button adjacent to each knob. Adjusting the setpoint level is therefore accomplished by pressing the push-button and adjusting the control knob until the required level is shown.

Each setpoint may independently be set to be active high or low and be latching or non-latching via the options bitswitch. The illuminated push-buttons flash when the alarm is activated and also act as reset switches when latched operation is selected. Pressing one of the push-buttons causes the alarm level to be displayed and resets the latched alarm, provided that the alarm condition no longer exists.

The relays and LEDs are forced into the non-alarming condition during the 32s self test period following the application of power. When power is removed from the equipment, the LEDs are not lit but the relays will go into the alarming state (fail-safe operation).

3.3 Liquid Crystal Display

The liquid crystal display (LCD) comprises four 12.5 mm high 7-segment characters with decimal points. It normally displays the gas concentration, but is also used to display other information as follows :

Condition	Display Reading
no power	blank
within 32s of power-on	self test sequence (see section 3.7)
test button pressed	“8.8.:8.8” (all segments on)
view alarm 1 button pressed	alarm level 1
view alarm 2 button pressed	alarm level 2
sensor fault	“Err”
low flow	“Err” or gas concentration *
normal	gas concentration

* depends on options bitswitch setting

Conditions are listed in priority order i.e. for simultaneous conditions, those higher up the table take priority over those lower down.

3.4 Front Panel Indicators

There are four illuminated indicators on the instrument front panel. The two yellow indicators show the state of alarms 1 and 2 (flashing when alarm active). The two red indicators flash to show that there is a fault with the instrument or that the gas flow is too low. The fault indicator illuminates to indicate that there is a fault with the gas sensor or its associated electronics. If the low flow indicator illuminates, this may be caused by a blockage or restriction in the particle filter or pipework attached to the gas inlet/outlet or a fault with the pump.

3.5 Test Button

The TEST button is located under the terminal compartment cover. This is used to perform a display test and pressing the button turns all the display segments on, illuminates all the indicators and operates the buzzer. The status of the other outputs (relays and analogue output) are unaffected.

3.6 Analogue Output

The analogue output is a current source and may be used to connect to external indication, control or data logging devices. The output can be configured to provide a 4-20 mA linear, 0-20 mA linear or 0-20 mA non-linear output using the options bitswitch (see section 3.1). The output options behave as follows:

Output Setting	4-20 mA	0-20 mA
Zero Reading	4 mA	0 mA
Span Reading	20 mA	20 mA
Max over-range	25.5 mA	22 mA
Max under-range	3 mA	0.5 mA *
Fault Condition	0 mA	25.5 mA

* negative values are indicated as positive current

The output over-ranges (with reduced accuracy) up to 25.5 mA (4-20 mA) or 22 mA (0-20 mA). The guaranteed output drive capability is 11V leading a recommended maximum load of 430 ohms for full analogue output functionality. A 500 Ω load may be used to achieve a 0-10V output, however the 11V limit means the fault indication on the 0-20mA setting (25.5mA) is not available. Under open circuit conditions the output may rise to 15.5V maximum.

A voltage output may be achieved by adding resistors across the output. If the analogue output is to be used to drive a device requiring a voltage input, it is recommended that the current sense resistor(s) are fitted at the remote equipment rather than at the Guardian Plus. This eliminates the effect of any voltage drops down the interconnecting wires and improves immunity to noise. Using the highest possible output voltages is also recommended in order to maximise immunity to noise. Using the current output to generate full scale voltage signals below 100 mV is not recommended as this may make the overall system susceptible to noise.

Two parallel connected resistor positions (R45 and R46) are provided on the main PCB under the terminal compartment cover allowing the resistors to be fitted internally if required. The pads for the resistors use

plated-through-holes allowing the resistors to be fitted without removal of the main PCB from the case provided this task is approached with care. Fitting of resistors to the PCB should be performed by a qualified electronics engineer. Only high quality resistors (metal film or wire-wound recommended) with the following specification should be used :

tolerance	< ± 1%
temperature coefficient	< ± 50 ppm/°C
power rating	> 0.25 W

The value of the resistor(s) depends on the required output, some standard values are:

Output Voltage	R45	R46
0-100 mV	10 Ω	10 Ω
0-1V	100 Ω	100 Ω
0-3V	not fitted	150 Ω
0-5V	820 Ω	360 Ω

3.7 Power-On Self Test Sequence

When power is connected to the Guardian Plus, it executes a self-test and warm-up sequence as follows:

Time	Display	LEDs	Buzzer	Relays	Analogue Output
0-1s	Software Version	Off	Off	Non-Alarming	0 mA
1-2s	8.8.:8.8	Off	Off	Non-Alarming	0 mA
2-3s	Countdown	On	On	Non-Alarming	0 mA
3-32s		Off	Off	Non-Alarming	0 mA

Note : the relays are energised in the non-alarming state so that they go into the alarming condition when power is removed from the equipment (fail-safe operation). The relays can therefore be heard to operate and go into a non-alarming state when power is first applied.

3.8 Relay Outputs

The alarm and fault relays may be connected to external control or annunciation equipment. The relay outputs are suitable for direct connection to the standard single-phase mains supply since the relays used have a 5 kV coil/contact isolation and the PCB track clearances exceed 6mm.

Relays are generally designed either for power or low level signal switching applications. The contact requirements for these two applications are different and are generally incompatible. The Guardian Plus however has been designed for use in either application. The relay contacts are made from a gold plated silver based alloy making them suitable for either low level switching or high power switching applications. If the relays are used in power switching applications, they should not subsequently be used to switch low level signals as arcing may have damaged the gold plating.

The relay contacts are designed to switch the following resistive loads :

mains power switching	8A @ 250 VAC maximum
DC power switching	8A @ 24 VDC maximum
signal switching	10 mA @ 5V minimum

For other voltages, the following limits should be observed :

maximum switching voltage	380 VAC, 150 VDC
maximum carrying current	10 A
maximum switching current	10 A
maximum switching power	2000 VA, 192 W

Life expectancy (normally 100,000 operations) of the relays will be reduced if used to switch inductive loads.

3.9 Mains Voltage Selection Switch

The mains voltage selection switch (SW3) is located in the top left hand corner of the main PCB, just above and almost obscured by the mains transformer. Before attempting to access the switch (see section 4.2 for access details), all mains power should be removed from the Guardian Plus.

The voltage selection switch has only 2 positions and selects between mains supplies of either 88 to 138 VAC or 172 to 276 VAC, this should cover all mains supplies encountered. After making a change to the voltage selection switch, the rating plate on the outside of the case must be modified to indicated the new supply setting.

4.0 Maintenance & Calibration

It is recommended that preventative maintenance should be performed annually, this requires approximately fifteen minutes. More frequent maintenance may be required when equipment is operated in adverse environments. Preventative maintenance comprises a calibration check (see section 5.0) and replacement of the particle filter (see below)

4.1 Filter Replacement

Access to the particle filter capsule is obtained by unscrewing the knurled gas inlet/filter housing. Remove used filter capsule (twist and pull) and replace with a new capsule then re-fit the filter housing. A spare filter capsule including integral seal is provided with each monitor. Further replacements can be purchased from your supplier quoting part number 99000, capsules without integral seals must not be used.

Warning : Do not operate the unit without a filter as this may cause permanent damage to the sensor.

4.2 Getting Inside The Guardian Plus

Warning : This apparatus operates from the mains electrical supply (230V or 115V). Take care to avoid electric shock.

To get inside the Guardian Plus :

1. Note the alarm setpoint levels for later use.

2. Switch off and isolate the mains supply to the instrument, including supplies associated with the relay outputs.

3. Unscrew the two plastic retaining screws which secure the transparent door covering the front display/control panel and swing open the hinged door.

4. Remove the two threaded spacers and the two M3 screws which secure the front display/control panel (retain screws and washer for refitting). Lift away the front panel by gently pulling on the setpoint control knobs. The electronics behind the front panel are connected to the main PCB by a ribbon cable.

5. Detach the ribbon cable at the main PCB using the jacking handles (use fingers to separate the clips at either side of the connector, this ejects the ribbon connector).

4.3 Removing Main PCB

Removal of the front panel allows access to the main PCB sufficient to perform most service operations (mains voltage adjustment, fuse replacement, pump replacement, secondary filter replacement). For more major repairs, it may be necessary to remove the main PCB, as follows :

1. Check that the mains supply is switched off and isolated. Remove the terminal compartment cover and disconnect all connections to the terminal blocks (taking note of connections for re-fitting later).

2. Disconnect the two neoprene pipes between the PCB and the enclosure (gas inlet to pump and flow sensor to exhaust).

3. Disconnect the buzzer from the main PCB by pulling the connector from PL5.

4. Remove the screw in the centre plus the five M3 screws around the edge of the PCB (retain screws and washer for refitting). Slide the main PCB out by lifting out the top edge first.

To refit, reverse the above procedure. Ensure all connections are correct and secure before re-powering the instrument. Check the alarm setpoint levels as these may have been disturbed during dis-assembly.

The Guardian Plus has been designed to the highest safety standards, and the danger of coming into contact with the live conductors in normal use is minimal. However, we do not recommend that the unit be operated outside its case as this forms part of the protection against electric shock.

4.4 Fuse Replacement

There are two fuses in the Guardian Plus, both are located on the main PCB (see section 4.2 for access instructions). When replacing fuses, use only 20 mm, anti-surge (indicated by the character T before or after the fuse rating). Other faster fuses may blow during switch-on. The fuse holders can be opened using a broad bladed screwdriver, press down and rotate 1/8 turn anti-clockwise to remove fuse. Fuse details

Reference	**Function**	**Rating**
F1	main supply inlet	200 mA T
F2	transformer secondary	1A T

4.5 Pump Replacement

The pump is located on the main PCB (see section 4.2 for access instructions) and may be replaced as follows :

1. Disconnect the pump from the main PCB by pulling the connector from PL4.

2. Detach the pump by removing the two screws at opposing corners of the pump bracket which hold the pump to the PCB. The screws fit into inserts which are permanently attached to the main PCB.

3. Withdraw pump and transfer neoprene pipes to the new pump (inlet and outlet are marked on pump, the outlet should be connected to the sensor head).

4. Reverse step 2 and 1 to complete the replacement.

4.6 Cleaning

The exterior of the case may be cleaned using a soft cloth moistened in water to remove smudges and dust. For more persistent marks, a soft cloth moistened in isopropyl alcohol may be used. The use of more aggressive solvents or abrasive cleaners is not recommended.

5.0 Calibration

The Guardian Plus is inherently stable and will maintain its calibration over extended periods with minimal maintenance. In normal use, the calibration should be checked every 12 months. Any adjustment should be small.

5.1 Calibration Gas Accuracy

> Important Note : Never connect gas cylinders (even with regulators) or other pressurised gas sources directly to the instrument, as the pressure may damage the unit.

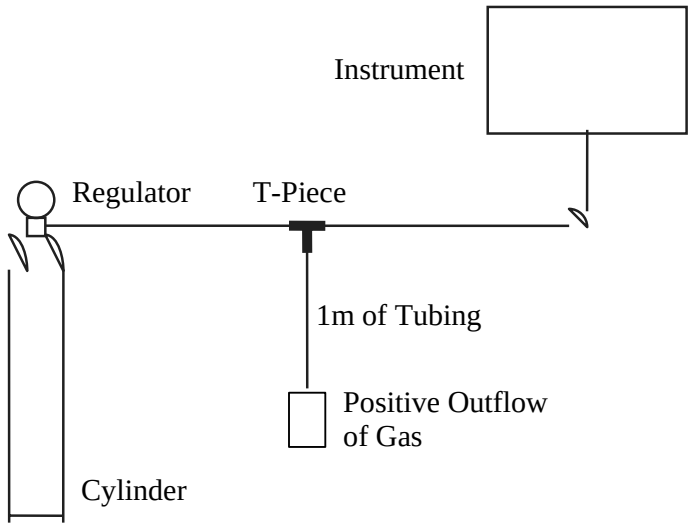
In order to check or adjust the calibration of the Guardian Plus, you must supply gas of a known composition to the instrument. The accuracy of the gas used governs the accuracy of the calibration. Factory calibrations are performed with gas analysed to ±1% of value, which is the highest standard available commercially. For gas mixtures supplied in small disposable canisters, the best available analysis is ±2%. Lower grades are available (up to ±20% accuracy) at lower cost, we recommend that the best available analysed gas mixtures are used for all calibration operations.

5.2 Connecting Calibration Gas To The Guardian Plus

To connect gas to the Guardian Plus, supply the gas to the instrument via a pipe with a T-Piece and a 1 m pipe running off and venting to atmosphere. This prevents overpressure being applied to the unit and

allows the pump in the Guardian Plus to draw in the required gas flow with the excess venting off. The 1 m line is necessary to prevent back flow of air into the system.

Make sure that there is a positive outflow at the vent pipe either manually (with a wet finger) or with a flow meter.



5.3 Effects Of Pressure On Calibration

Because gases are compressible, there are various ways of expressing the gas concentration (volume percent, partial pressure, density, mole density). Infra-red gas analysers operate by measuring the amount of infra-red energy absorbed by the gas and this is fundamentally related to the mole density (the number of molecules in the beam path).

Most users calibrate their equipment using gas mixtures supplied in cylinders which fundamentally provide constant volume percent mixtures. The relationship between mole density and volume percent depends on the ambient pressure and temperature. If an infra-red monitor is checked periodically against a cylinder of calibration gas, the reading would appear to change with the error being related to the pressure and temperature. The Guardian Plus measures the temperature of the sensor head and performs temperature compensations to eliminate this factor, so

the only systematic error arises from variations in pressure. This effect is directly proportional to the absolute pressure.

In addition to the "ideal gas" effects discussed above there is also a small pressure dependence caused by an effect known as collision broadening in which the infra-red absorption of a gas is dependant on the total pressure as well as the mole density of the measured component. Collisions between the molecules broaden the infra-red absorption and the increased number of collision that occur at higher pressure therefore leads to an increased absorption and higher apparent gas reading. This second order effect increases the reading by approximately 0.5% for every 1% change in absolute pressure around normal atmospheric pressure.

All factory calibrations take into account the pressure when the calibration is made and normalise the readings so that the instrument would read correctly for standard sea level pressure of 1013.25 mBar (101.325 kPa). It is possible to obtain the true reading from the display value using :

$$True\ \%v/v = Display \times \left\{ \frac{P_0}{1.5 \times P - 0.5 \times P_0} \right\} = Display \times \left\{ \frac{1013.25}{1.5 \times P - 506.62} \right\}$$

where P = ambient pressure (mBar)

$P_0 = 1013.25\ mBar$

When calibrating the sensor, the reverse correction needs to be made (see below)

5.4 Calibration Procedure

Before performing a calibration, read the above section on the effects of pressure on calibration.

The Zero and Span adjust potentiometers are located on the main PCB and may be accessed by removing the terminal compartment cover. The position of the potentiometers is monitored by the internal microprocessor and they are set to mid-position during factory calibration

to allow maximum field adjustment. It also enables any field adjustment and its extent to be checked on return to the factory.

Calibration procedure :

1. Power the Guardian Plus for at least one hour before checking the calibration.

2. Apply zero gas i.e. gas containing none of the gas measured by the instrument (nitrogen recommended) to the inlet port (see section 5.2 above) and allow the display to settle for at least one minute. If the instrument's zero reading is out of specification, adjust using a suitable tool on the ZERO adjust potentiometer.

3. Apply a gas mixture containing a known, near span concentration (between 80% and 100% of instrument full scale). For maximum accuracy, correct the stated bottle concentration for the effect of pressure using :

$$Corrected\ Concentration = Bottle\ Concentration \times \left\{ \frac{1.5 \times P - 0.5 \times P_0}{P_0} \right\}$$

$$= Bottle\ Concentration \times \left\{ \frac{1.5 \times P - 506.62}{1013.25} \right\}$$

where P = ambient pressure (mBar)

$P_0 = 1013.25\ mBar$

4. Allow the display to settle for at least one minute. If the instrument's reading is out of specification, adjust using a suitable tool on the SPAN adjust potentiometer.

Example:

If the ambient atmospheric pressure is at 980 mBar then the corrected span gas concentration for a 3000 ppm span calibration bottle would be:-

$$Corrected\ Concentration = 3000 \times \frac{1.5 \times 980 - 506.62}{1013.25} = 2852\,ppm$$

This means that instead of adjusting the instrument to read 3000 ppm at span it should be adjusted to read 2852.

Since the measurement of ambient pressure affects the calibration of the instrument, it is vital that this is measured accurately. In general, aneroid barometers (the mechanical type often used in domestic applications) are not sufficiently accurate. Mercury barometers are generally sufficiently accurate if used properly (remember to compensate for temperature and the local effective gravitation). Reliable electronic barometers are now available at reasonable cost - consult factory for advice. If you use a pressure figure from a remote location (by asking someone with a barometer) remember to correct for the altitude difference. If you use figures given by an airport or meteorological office, remember that these are sea-level corrected values and correct for your actual altitude.

If a value for the local ambient pressure is not available or you do not require optimum accuracy, ignore the effect of pressure and set the Guardian Plus to the value given on the calibration certificate for you gas. Ambient pressures change by about ±3% from day to day at any given location, the consequences of ignoring pressure effects will therefore be less than ±5% on the absolute calibration accuracy.

6.0 Trouble Shooting

> Warning : This apparatus operates from the mains electrical supply (230V or 115V). Take care to avoid electric shock.

Servicing should only be performed by a qualified electronics engineer. The following table lists common fault symptoms and recommended actions:

Symptom	**Recommended Action**
completely dead (no noise from pump)	• check power reaching instrument • check input fuse F1 - see sections 4.2 & 4.4 • check voltage selection switch correctly set
pump noise but no other signs of life	• check secondary fuse F2 see sections 5.0 & 4.4
display reads “Err”, buzzer & low flow lamp on	• check / replace filter - see section 4.1 • if fault persists, check / replace pump - see section 4.5
alarm permanently on	• check if latched alarm selected - see section 5.0
no analogue output	• is 0-20 mA output selected & gas concentration ≈ 0 - see section 3.1
analogue output incorrect	• check if non-linear output selected - see section 3.1
readings not as expected	• check calibration - see section 5.0
display reads “Err”, buzzer & fault lamp on	• arrange service

7.0 Safety & System Integrity

The exhaust gas from the Guardian Plus monitor is normally vented into the local atmosphere. If this presents a hazard, particularly to personnel safety, the gas should be vented safely by attaching suitable tubing to the outlet nozzle - see section 5.2 .

Components of the sampled gas, including those not measured by the Guardian Plus, should be assessed for toxicity, flammability, risk of explosion and asphyxiation as well as any hazards specific to the installation (biological, nuclear, etc.). The gases which can be measured by the Guardian Plus present the following hazards:

Gas	Gas	Hazard	Limit
Carbon Dioxide	CO_2	Asphyxiant	0.5% (8 Hour Exposure Limit)
Methane	CH_4	Explosive	5% (Lower Explosive Limit In Air)

The Guardian Plus performs continuous self-checking. If a fault is detected, the audible alarm sounds and the fault is indicated on the front display panel. In addition the relay and analogue outputs are forced into a particular state (controlled by the options bitswitch) so that external equipment using these outputs can detect the fault and take appropriate action - see section 3.1 for further details. If the Guardian Plus is used with external equipment to provide a control or alarm function, the user should ensure that the equipment and wiring make use of the fault annunciation facility so that the system responds appropriately to a fault condition. Catastrophic faults in the Guardian Plus may mean that a fault is not indicated, this should be considered by the user in the system design.

7.1 Toxic Gases

Where gas sensors or gas monitor equipment is used with atmospheres which contain asphyxiant, toxic or explosive gas components, it is the responsibility of the user/installation engineer to investigate and to execute all appropriate measures necessary to eliminate the risks to health resulting from the use of this equipment, or resulting from a leak or fault created within or through the use of our equipment.

Gas	Gas	Hazard	Limit
Carbon Dioxide	CO_2	Asphyxiant	0.5% (8 Hour Exposure Limit) Concentrations of 10% (100,000 ppm) or more can produce unconsciousness or death
Methane	CH_4	Explosive	5% (Lower Explosive Limit In Air)
Carbon Monoxide	CO	Asphyxiant	Lethal at 1%

8.0 Specification

Range:

CO_2	0-3000 ppm
	0-5000 ppm
	0-3%
	0-5%
	0-10%
	0-25%
	0-30%
	0-100%
CH_4 [2]	0-5%
	0-10%
	0-30%
	0-100%
R125/R22	0-1000 ppm

Accuracy: [1] < ± 2% of full scale
Response Time: T_{90} < 30s from sample inlet
Operating Temperature Range: 0-40°C
Warm-up Time:

Operational	1 min
Full Specification	30 mins

Humidity Range: Unaffected by 0-100% RH (non condensing)

Power Supply (Switch Selectable):
230 VAC (±26%) / 46 to 66 Hz
115 VAC (±26%) / 46 to 66 Hz
Power Consumption: 13W typical

Alarm Ranges: zero to full scale

Controls:
alarm 1 adjust
alarm 2 adjust
view alarm level 1 button
view alarm level 2 button
zero adjust
span adjust
lamp test button
options bitswitch

Outputs:
4-20 mA/0-20 mA analogue output
11V guaranteed drive capability
Alarm 1 relay, Alarm 2 relay & Fault relay
SPCO (single pole change-over)
voltage free contacts rating:
8A at 250 VAC (resistive load)
8A at 24 VDC (resistive load)

Enclosure rating: IP54

Dimensions : 267 x 258 x 148 mm

Weight: 2.5 kg

NOTES:
1. Accuracy does not include calibration gas accuracy.
2. This equipment is not-suitable for use in/with explosive atmospheres.
3. Precautions must be taken where there is a risk of asphyxiation (see section 7.1).
4. This equipment is specified for use in air and air like backgrounds.

9.0 Accessories and Spare Parts

Part Number	Description
99000	Particle Filter With Integral Seal
9902	Guardian Plus, 12 VAC Pump
75155	Guardian Plus Enclosure **without** buzzer
75165	Guardian Plus Enclosure **with** buzzer
9900	RS232 Interface Adapter

10.0 Warranty

Edinburgh Instruments Ltd is an ISO9001:2000 registered company, your Guardian Plus has been manufactured in accordance with our quality system. The product should only be operated in accordance with this manual and other documentation supplied by the manufacturer.

Edinburgh Instruments Ltd guarantees the equipment against defective materials or workmanship for a period of one year from the date of delivery. Exceptional operating conditions, damage due to careless handling, modifications made by the owner or misapplication will void the guarantee.

In no event shall Edinburgh Instruments Ltd be liable for any consequential loss or damage arising from the failure of the equipment under warranty. At the end of the warranty period, all liability for failure of the equipment shall be absolutely at an end.

In the event of a fault occurring with the Guardian Plus the equipment should be returned to the authorised dealer from whom it was originally purchased. For equipment being returned directly to Edinburgh Instruments Ltd, please contact out Sales Department for an RMA number (Returned Materials Authorisation) which will ensure that your equipment is dealt with promptly by our service department. All shipments must be pre-paid, properly packed, insured and clearly labelled with the RMA number.

NOTE:
If the equipment to be returned has been in contact or used with a hazardous to health substance (covered by COSHH regulation), Edinburgh Instruments Ltd must be notified in advance as this could constitute a health risk/hazard to our personnel.

CE

11.0 CE Mark Details

The Guardian Plus unit has been CE marked to indicate compliance with all essential requirements of the Directives referenced.

2006/95/EC	Conforms with the safety objectives of the Low Voltage Directive and its amending directives
2004/108/EC	Conforms with the essential requirements of the Electromagnetic Compatibility Directive and its amending directives.

The Guardian Plus is intended for use in commercial and light industrial environments and the following standards have therefore been applied:

BS EN 61000-6-1:2007	EMC immunity for residential, commercial and light-industrial environments
BS EN 61000-6-3:2007	EMC emission standard for residential, commercial and light-industrial environments
BS EN 61010-1:2001	Safety requirements for electrical equipment for measurement, control and laboratory use

12.0 Document Change History

ECN	DATE	ISSUE
Original	April 1997	1.1
6540	May 2004	1.2
6661	Dec 2005	1.3
6895	March 2009	1.4