Z230

Zirconia Oxygen Analyser

130-0186

Instruction Manual

This Manual Contains Important Health & Safety Information.

Contents

1 DECLARATION OF CONFORMITY

We declare under our sole responsibility that the Hitech Instruments Z230, conform to the requirements of the Directives below by compliance with the standards listed:

1. **Council Directive 2004/108/EEC (EMC Directive) relating to Electro-Magnetic Compatibility,**
   EN 61326-1:2006
   Class B emissions: Basic immunity
2. **Council Directive 2006/95/EEC (Low Voltage Directive),**
   EN 61010-1:2001.

	Signed:	J.Gass
		J. Gass Managing Director
	Signed:	H.J.Podgorney
		H.Podgorney Design Manager

02/06/2009	**Hitech Instruments Limited** Great Marlings, Butterfield Luton, England, LU2 8DL. Tel. (0)1582 435600 Fax (0)1582 400901	HITECH INSTRUMENTS

2 INTRODUCTION

2.1 General Description

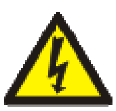
The Z230 is a microprocessor controlled oxygen analyser based on a Zirconia oxygen sensor. It provides a range of features and a performance without parallel for an analyser of this type and cost. Standard features include auto-ranging over a span of 100% to 0.01ppm, user programmable alarm levels, hysteresis and analogue output. The unique sensor and heater design gives very fast warm-up times, rapid response, and long sensor life.

The instrument measures oxygen over the range of 0.1ppm to 100% in non-reactive gases (nitrogen, argon etc). Standard features include an auto-ranging display over the full span of the instrument, user programmable alarm levels, hysteresis and analogue output.

NOTE: the Relay operation and labelling "Normal" relates to process normal and not the electrical rest position of the relays. In process normal the relays are energised.

Definition of Equipment Symbols

This symbol alerts you of a potential hazard. Refer to manual.



This symbol alerts you to the presence of hazardous voltages. Refer to manual.

The following symbols are used in this manual

WARNING:
These are used in this manual to ensure operator safety and must be followed.

CAUTION:
These are used in this manual to warn and prevent damage to the instrument.

NOTE: These are used in this manual to give general information to ensure correct operation.

2.2 Information

Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC

(RoHS Directive 2002/95/EC

WARNING:

This equipment must only be used in accordance with the manufacturer's specification, instructions for installation, use and maintenance to ensure that the protection of the operator is not impaired. It is the responsibility of the installer to ensure the safety and EMC compliance of any particular installation.

2.3 Warranty

Hitech Instruments Ltd warrants its products are free from defects in material and workmanship for a period of 1 year from date of shipment.

A warranty claim will not be honoured if defects are not reported within the warranty period or if Hitech instruments Ltd or its agents determines that defects or damage are due to normal wear, misapplication, lack of maintenance, abuse, improper installation, alteration or abnormal conditions.

Hitech Instruments Ltd obligation under this warranty shall be limited to, at its option, repair or replacement. Under no circumstances will Hitech Instruments Ltd be liable for any incidental or consequential damages whether to person or property. Hitech Instruments Ltd will not be liable for any other loss, damage or expense of any kind including loss of profits, resulting from the installation, use or inability to use this product.

The product must be returned freight prepaid for examination to Hitech Instruments Ltd or agent thoroughly cleaned and any process chemicals removed before it will be accepted for replacement or repair.

3 SPECIFICATION

Display
Multi digit LCD - character height 12.7mm

Display ranges
Display range 0.01ppm to 100% Oxygen, auto ranging

Display Resolution

From 100% to 103%	1%
From 10.0% to 99.0%	0.1%
From 1.00% to 9.99%	0.01%
From 0.100 to 0.999%	0.001%
From 100ppm to 999ppm	1ppm
From 10.0ppm to 99.9ppm	0.1ppm
From 0.00ppm to 9.99ppm	0.01ppm

Accuracy
±1% of reading or ±1mV sensor output, whichever is the greater

Stability
Better than 2% of full-scale per month

Sample flow
Between 100 and 300 ml/min for optimum operation

Speed of response
T-90 less than 4 seconds at 300ml/min sample flow

Sample inlet pressure (no pump fitted)
10mbar to 8bar

Sample temperature
100°C maximum at the analyser

Sampling system material
Dependant upon sampling system:
Stainless steel, platinum, zirconia, nickel, brass aluminium alumina, PTFE, nitrile-rubber and nylon

Sample connections
Dependant upon sampling system: Nickel plated brass (captive seal suitable for 6mm/0.25" O.D. pipe)
Brass double ferrule, stainless steel double ferrule.

Analogue output - isolated
0 to 5 volts – minimum load 10k ohms or
4 to 20mA – maximum load 500 ohms

Programmable for full scale values of between 1ppm and 100% oxygen and zero scale values of between 0ppm and 90%

Alarm outputs
2 alarms each user programmable for:
Mode - HIGH, LOW or OFF.
Level - full range of instrument.
Hysteresis - 0% to 10% of set point.
Volt free C/O contacts rated at 48v 0.5A AC or DC, normally energised

Serial Communication Port
RS232 DCE (9w female D connector)

Environment
0 to 45 °C operating temperature
15 to 90% relative humidity, non-condensing

Power supply
90-130 or 200-260V AC 50/60 Hz unit may be specified at the time of order, Maximum power consumption 30VA.

Dimensions
255mm (w) x 170mm (h) x 260mm (d)

4.1 Unpacking and visual checking

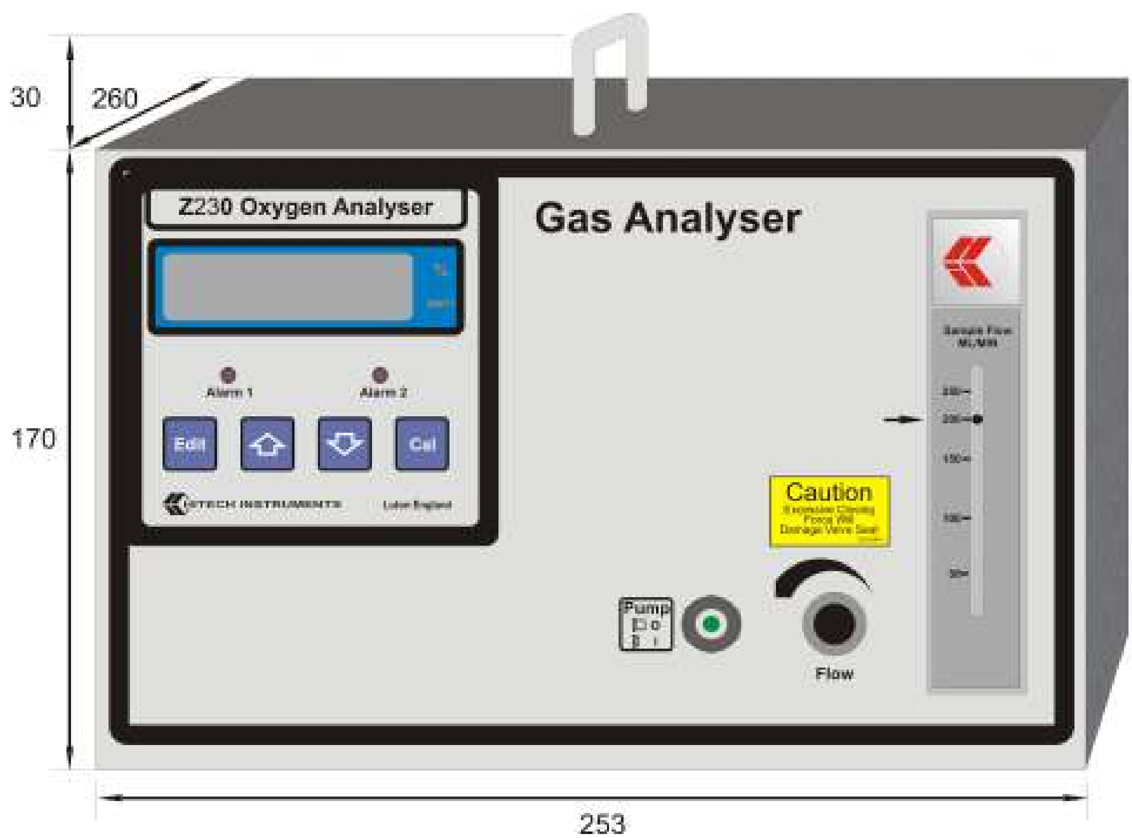
Take all normal precautions when opening packages. In particular avoid the use of long bladed cutters. Check for any sign of damage. Check that all pipe connections have captive seal nuts – search packing if any are missing.

4.2 Mounting

The instrument should be installed where free air ventilation around the whole case is provided. The ambient temperature should not exceed 45°C. Dust and dirt should be kept to a minimum. Ambient air must contain a normal Oxygen level.

WARNING: The case should not be exposed to water jets or drips.

Figure 1: Instrument dimensions



4.3 Sample

WARNING: IT IS IMPORTANT THAT NO FLAMMABLE MIXTURES ARE ALLOWED TO COME INTO CONTACT WITH THE MEASURING CELL AS THIS MAY CAUSE IGNITION OF THE GAS. GASES CONTAINING HALOGENS, SULPHUR OR SILICON, MUST BE AVOIDED. IT IS THE RESPONSIBILITY OF THE USER TO ENSURE THAT ANY ADVICE OFFERRED CAN BE SAFELY APPLIED TO THEIR PARTICULAR SITUATION

CAUTION: THE DEW POINT OF THE SAMPLE MUST ALWAYS BE LESS THAN THE AMBIENT TEMPERATURE TO AVOID THE RISK OF LIQUID DROPLETS FORMING IN THE MEASURING CELL

4.3.1 Key requirements

- The sample must not contain halogens, sulphur or silicon (silicones etc) as these will poison the sensor.
- The sample must be non-condensing, non-corrosive and particle free.
- The sample exhaust must be at or near atmospheric pressure in all cases.
- When applied to heat-treatment atmospheres containing combustible gases, care should be taken to ensure that the sample exhaust (sample out) is taken to a safe vent where there is no risk of ignition.

4.3.2 General advice

The instrument is supplied with one of several sample system types according to the duty defined by the original user. A label on the instrument shows the pressure limits and other data for the particular one fitted. This should be taken into account before applying a sample.

WARNING: Ensure you do not exceed the maximum sample pressure.

For permanently installed analysers it is advisable to fit an isolating valve in the sample delivery line so that the analyser can easily be removed for servicing. In cases where the sample exhaust is not vented to atmosphere then a valve may be required there too. The use of a three-way valve on the inlet side is also useful in allowing easy connection of other gases for calibration checks.

Dead-legs, particularly those present in Bourdon tube type pressure gauges, can take a long time to purge out as can small dead zones created by fittings etc. Unnecessary dead-legs should be avoided.

When the sample is from a pressurised source, the sample flow regulator valve must be fitted to the sample inlet pipe to avoid the risk of pressuring the cell.

Most analysers are supplied with a built-in sample flow-regulating valve. If a valve is fitted in the sample outlet pipe work it is important to remember that it must be the last to be shut.

4.3.3 Measuring low levels of oxygen

All piping should be of good quality material with sound joints and couplings. When measuring concentrations of less than 500ppm oxygen very small leakages can noticeably affect the readings- for ppm concentrations the piping must be of hard plastic or metal. Suitable plastics are Nylon and rigid P.V.C. Soft plastics, P.T.F.E. and flexible P.V.C. are not suitable. Cylinder pressure regulators should have a low volume and a metal diaphragm. Most pressure gauges etc. contain cavities that entrain air/oxygen and can take several hours to purge down, for this reason they should be avoided.

Flow regulating valves are typically poor shut-off valves and vice-versa. Multi-way valves can also be problematic, particularly if they have a source of pressurised high oxygen gas (air for instance) connected to one of their ports. If it is necessary to isolate a pressure regulator, a shut-off valve should be fitted to its outlet port.

If a pump is needed because the sample is at near atmospheric pressure, then it should be connected to the sample outlet and the sample drawn through the analyser, with the flow adjustment valve between the analyser outlet and the pump inlet. If the pump is placed at the sample inlet then it will need to be of a construction that will not contaminate the sample.

Flow meters can introduce leaks at these levels and should be installed in the sample outlet pipe work.

Before connecting a gas sample to the analyser it is advisable to thoroughly purge the external gas train.

4.4 Electrical connections

4.4.1 Supply

Power connections should be made to the instrument using the IEC lead supplied.

4.4.2 RS232 Connection

NOTE: See also section 8: Communication Protocol

DCE (instrument)			DTE (PC)	
signal	description	9W	25W	9W
GND	Signal gnd	5	7	5
RX	Data received by instrument	2	3	2
TX	Data transmitted from instrument	3	2	3

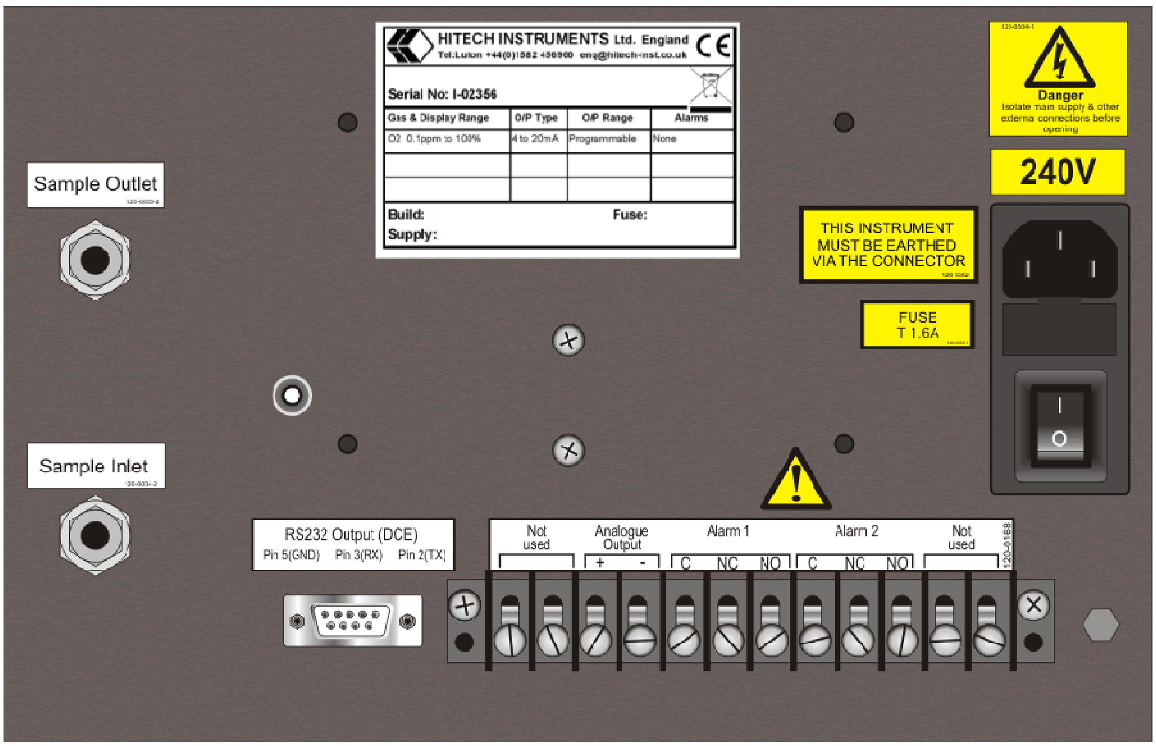
4.4.3 Alarm and Analogue Output connections

See figure 2

CAUTION: The recommended cable used for external connection is double insulated.

WARNING: Although relay contacts are rated at 48V AC or DC, voltages above **33V AC** are defined as hazardous by BSEN61010-1 (Safety requirements for electrical equipment for measurement, control and laboratory use). Appropriate precautions should be taken when connecting signals to alarm terminals.

Figure 2: Electrical and sample connections



5.1 Switching on

With the analyser is fully connected it may be switched on. The cell heater will begin to warm up. During this time the display will flash “HE xxxxx and the concentration display will make high and low excursions. Once the correct temperature is reached, the “HR” will end and the display will stabilise. Allow a further 15 minutes before relying on the oxygen reading. Note that the temperature controller settings are locked and no attempt should be made to change them.

5.2 Programming

NOTE: See figure 3

The user programmable features are accessed by pressing and holding the Edit button for approximately 8 seconds when the instrument is in normal measurement mode (as turned on). Each subsequent momentary press of the Edit button scrolls the display through a sequence of adjustable parameters. The sequence is as follows.

Analogue Output top scale value→ Analogue Output low scale value→ Alarm 1 Set point → Alarm 1 Hysteresis → Alarm 1 Mode → Alarm 2 Set point → Alarm 2 Hysteresis → Alarm 2 Mode→ wraps.

All Programming screens operate on the same principle

- use the “▲” or “▼” arrows to scroll through the parameters
- By pressing “Edit” and the x in the xP nnnn will flash then using the “▲” or “▼” arrows to edit the value. Pressing “Edit” saves change while “Exit” leaves values unchanged

5.2.1 Analogue output

1P xxxx

The display shows “**1P xxxx**”, where “xxxx” is the oxygen concentration at which the analogue output top scale is set at To the right of the display a % or ppm symbol is displayed to indicate the units of the value displayed

2P xxxx

The display shows “**2P xxxx**”, where “xxxx” is the oxygen concentration at which the analogue output bottom scale is set at To the right of the display a % or ppm symbol is displayed to indicate the units of the value displayed

5.2.2 Alarm 1

NOTE: All alarms will be in the 'alarm' state whilst the instrument is booting (approximately 20 seconds after power on) or if the instrument registers an error, regardless of the alarm setting.

3P xxxx
The display shows "**3P xxxx**", where "xxxx" is the oxygen concentration at which Alarm 1 is set. - observe the "%" and "ppm" symbols to ensure the correct setting.

4P xxxx
The display shows "**4P x.x**", where "x.x" is the value of the hysteresis for alarm 1. The value is in % of the set-point or alarm level and is variable from zero to 10%.

5P xxxx
The display shows "**5P x**", where "x" indicates the operating mode of the alarm as follows:-

'0' - Alarm off
'H' – High (alarm when **above** set point)
'L' - Low (alarm when **below** set point)
'S' – Status (alarm while cell heater is warming up)

5.2.3 Alarm 2

The operation of alarm 2 is identical to that of alarm 1. The menu entries are as follows:

6P xxxx
The display shows "**6P xxxx**", where "xxxx" is the oxygen concentration at which Alarm 1 is set.

7P xxxx
The display shows "**7P x.x**", where "x.x" is the value of the hysteresis for alarm 2.

8P xxxx
The display shows "**8P x**", where "x" indicates the operating mode of the alarm.

Quick start menu of Z1030 Oxygen Analyser

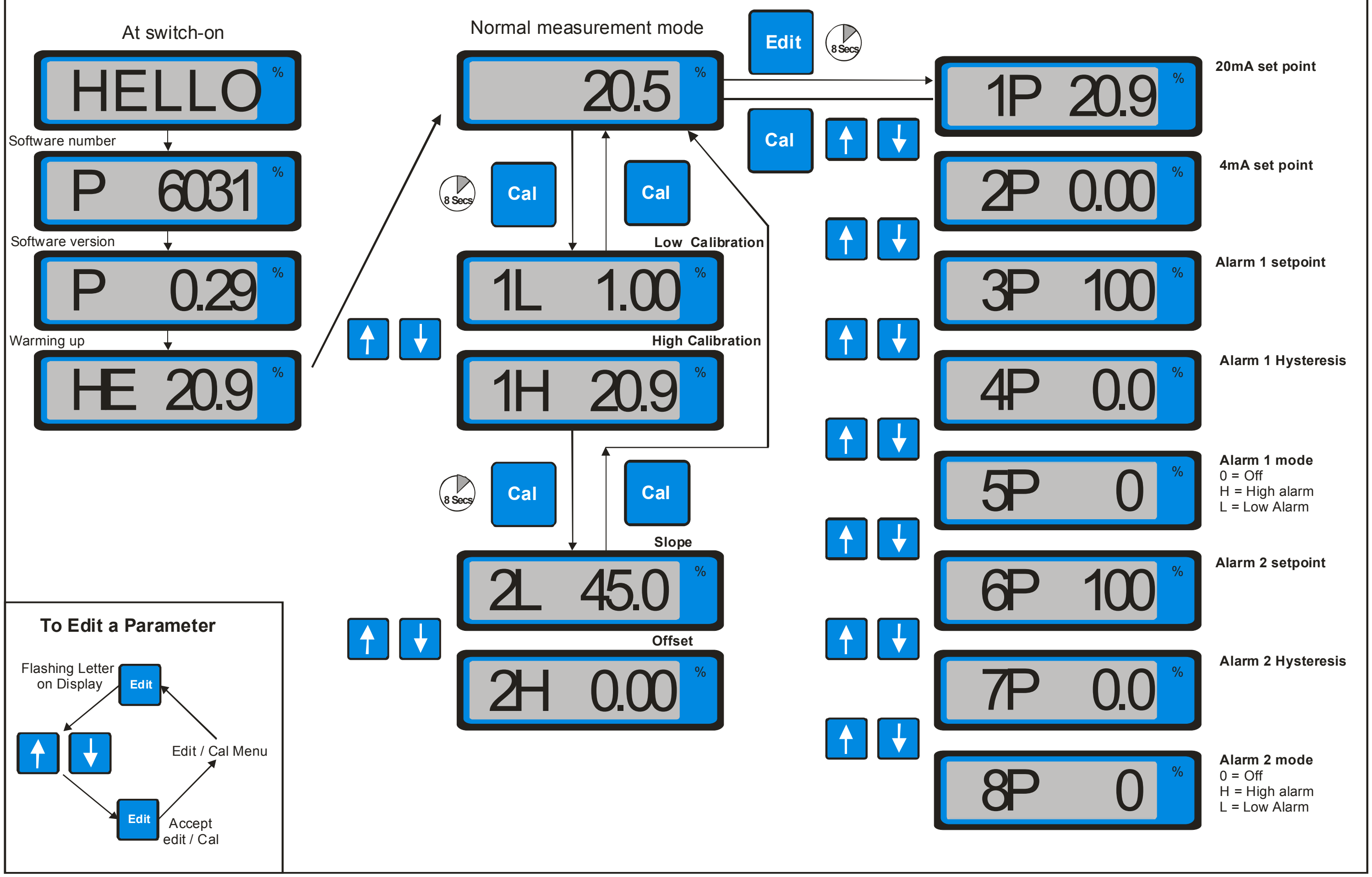


Figure 3 : 230 series menu

6 CALIBRATION

CAUTION: various procedures associated with calibration maintenance affect the outputs of the instrument. Any of these outputs that are being used for control (or the associated control loop) should be disabled before commencing.

6.1 Calibration overview

The Z230 is a very stable analyser with a drift rate of better than 2% of reading per month. How often the calibration is checked or verified depends on the quality regime being operated at the installation site. Typically monthly checks are found to be adequate.

It is preferable to use a calibration technique that starts by checking or verifying the response of the analyser and only altering the calibration of the analyser if the errors are significant. The readings may be verified by introducing a gas mixture of known concentration (calibration gas), and checking that the reading is correct after allowing the system to stabilise.

A full calibration requires two standard gases to set two points that are equivalent to zero and span. (See section 8 for a technical description of the sensor and how it works). The gas calibration points are referred to as high(H) and low(L). It is usual, mainly because of convenience, to use air as the “high” gas. The “low” gas should ideally have approximately the same oxygen concentration as the normal sample.

As with most instruments of this type it is important to have a reasonable concentration difference between the two calibration points. For the Z230 the recommended difference is 0.25 decades, i.e. LOG (H concentration/ L concentration) > ±0.25.
Because the most common high level gas is air, in order to maintain an adequate difference in concentration, the instrument will not accept a “low” level calibration gas between 10% and 40%.

6.2 Calibration gases

Because the sensor operates at high temperature, the calibration gases must not contain any flammable or reactive components. Typically this means using mixtures of oxygen with nitrogen. Refer to section 3.3 for sample connection and handling precautions.

Instrument grade compressed air (i.e. clean, dry and oil free) is frequently the most convenient gas to use for the upper concentration. Clean dry air has an oxygen content of 20.95%. If moist air is used then its water content must be allowed for. For example air at 20°C and 70% relative humidity (typical room air) contains 1.6% water. This will lower the oxygen content of the air by dilution to 20.6%.

It is important that the analyser IS NOT ZEROED in the conventional manner using a 'zero' grade gas. This is because the notion of zero oxygen has no real meaning for sensors of the type used in this analyser (See Section 7 – Technical

description of sensor). We recommend that the standard gas contains at least 5ppm oxygen and only ppb levels of combustibles.

6.3 Calibration procedure

NOTE: see Figure 3

All calibration screens operate on the same principle :-

- The display shows the present reading. This may be changed by pressing "Edit" and then using the "▲" or "▼" arrows to adjust the value.
- "Edit" saves change.
- "Cal" cancels the change.

6.3.1 'High point' calibration

Expose the process side of the cell to air at normal ambient pressure.

Press and hold the "Cal" button for about 8 seconds until the display changes to show "**1L xxxx**", where "xxxx" is the gas concentration measured by the instrument (if the button is released before the display changes then the analyser will remain in normal measuring mode).

Cycle through the menu entries using the "▲" or "▼" arrows until display shows "**1H xxxx**" (pressing "▼" at the bottom of the menu returns you to the top).

When the reading has stabilised, press the "Edit" button and use the "▲" or "▼" arrows to adjust the reading to the correct level, then press the "Edit" button to store the calibration setting (or "Cal" to cancel).

To return the unit to measuring mode press and release the "Cal" button, otherwise the "▲" or "▼" arrows until the display changes to "**L xxxx**" to continue with setting the "Low" calibration point.

6.3.2 'Low point' calibration

Change the sample gas supply to the "Low" level concentration and establish a flow of the gas through the analyser.

In **measuring mode**, Press and hold the "Cal" button for about 8 seconds until the display changes to show "**1L xxxx**".

In **high point calibration**, use the "▲" and "▼" arrows until the display changes to "**L xxxx**".

When the reading has stabilised, press the "Edit" button and use the "▲" or "▼" arrows to adjust the reading to the correct level, then press the "Edit" button to store the calibration setting (or "Cal" to cancel).

With the calibration complete press and release the "Cal" button to return the unit to normal measuring mode.

NOTE: Calibration limits are set in the software that prevents the user from adjusting the readings too far away from where the sensor output would indicate. When these limits are reached the displayed value will stop changing.

7 MAINTENANCE

Calibration is the only routine operation that is necessary on a regular basis.

The measuring cell’s response will eventually become sluggish necessitating a change of cell. The instrument should be returned to Hitech or their agent for a replacement to be fitted.

WARNING: OPENING THE ANALYSER CASE WILL EXPOSE YOU TO MAINS VOLTAGE. DISCONNECT THE ANALYSER FROM THE MAINS SUPPLY AND ANY POTENTIALLY HAZARDOUS PROCESS WIRING BEFORE OPENING THE CASE

7.1 Ordering parts

Should a failure occur, return the instrument to Hitech Instruments Ltd or their local agents for repair. When ordering spares or raising queries on the instrument, it is important to quote its serial number or job number. These numbers are on the data label located on the rear panel of the instrument.

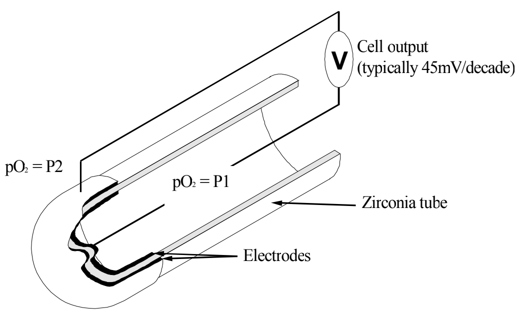
Hitech Instruments Ltd,
Great Marlings, Butterfield, Luton, England, LU2 8DL.
Telephone: (+44) 01582 435600
Telefax: (+44) 01582 400901
e-mail: enq@hitech-inst.co.uk

8 TECHNICAL DESCRIPTION of SENSOR

The Hitech Instruments zirconia oxygen sensor (see sketch below) is an impervious tube-shaped zirconia (zirconium oxide) element with a closed end coated externally and internally with porous metal electrodes, typically platinum. At high temperatures, typically above 400°C, the zirconia becomes an oxygen ion conductor, which results in a voltage being generated between the electrodes which is dependent upon the differences between the partial pressures of the oxygen in the sample and the oxygen in a reference gas (generally air). The voltage generated is determined by the Nernst equation:-

$$\text{Cell output} = \frac{2.303RT}{4F} \log \frac{P1}{P2}$$

where:-
R= molar gas constant
T= absolute temperature of cell in °K
F = Faraday constant
P1= partial pressure of oxygen in the reference (air in most cases)
P2 = partial pressure of oxygen in the sample.



Thus, with air on both sides of the cell, the output is zero (log1=0).

The reference electrode is negative with respect to the sample electrode for sample concentrations of oxygen higher than that of air and positive for concentrations less than that of air. Depending on the application either the internal or external electrode is used as the reference.

The output voltage is processed electronically to provide signals suitable for display or for process control purposes.

9 COMMUNICATION PROTOCOL

Communication parameters are 9600 Baud, 8 bits, no parity, 1 stop bit and no handshaking. The instrument is DTE. The general form of the protocol is:

1. The protocol is a single command and response protocol.
2. A command consists of an “address” and an “action”. A received valid address is always responded to even if the action is invalid. Commands must be single you cannot send multiple commands without awaiting a response.
3. A Response consists of a “tag” and “data”.
4. A command message can not be more than 30 characters without message terminator (<CR><LF>). Exceeding this length will result in an error 90. response
5. A response message can not be more than 30 characters without message terminator (<CR><LF>). Exceeding this length will be assumed to be a communications error.
6. A command message timeout is defined as 10 seconds. This is the maximum time from a valid address “Ax” to the message terminator (<CR><LF>). This time is long to allow keypad entry (i.e. HyperTerminal)
7. The response message failure to respond timeout is defined as 300 milliseconds. This is the maximum time from a valid command message terminator (<CR><LF>). Until the first character of the response.
8. A response message line maximum duration is defined as 1 second. This is the maximum time from the first valid response character to the line message terminator (<CR><LF>).
9. A response message maximum duration is defined as 3 second. This is the maximum time from the first valid response character to the last message terminator (<CR><LF>). This is to allow multiple line responses. No card response can hold the bus for more than 3 seconds. Factory commands are the only exception
10. exceptions to 7,8,9
    - Starting up: The card start up is defined as taking up to 10 seconds. The card will then assert an error “97” in R1, R4 and R5 on the first reading after the 10 second period. Subsequent readings will show the correct values.
    - Calibration exemption from paragraph 7 and 8 but must comply with paragraph 9.

The general form of the response is:

1. Read whole group: ‘AxP0’ where x is the network address of the unit. The unit will respond when x is its own address or 0 (any unit responds to address 0), otherwise it will not respond at all. If No Zero Param bit in sysflags is set, ‘AxP’ OR ‘AxP0’ to send all.
2. Read specific group item: ‘AxPy’ where y is the line (or item) number
3. Write specific group item: ‘AxPy=<new value>. The format and (where appropriate) precision of the new value is as it is displayed. With the ‘verbose’ flag cleared: Py itemname=value unit
4. With the ‘verbose’ flag set: Py =value
5. A read command will return 0 when it has no value to report (e.g. A0E6 returns A0E6=0)
6. A ‘do now’ write command (e.g. clear logs ‘E6’) will do nothing if set with a 0 as argument, will execute with a 1 as an argument and will ?93 any other argument. A ‘do now’ write command returns 0 for fail and 1 for success. E.g. A0E6=1 returns A0E6=1

Table 1 common groups

Send	Function	Reply (verbose)	Reply (terse)	Limits (where applicable)	Notes
Ax**C**y	**C**alibration	C9 Load def=0 C8 Sens 2 os=0.00 C7 Sens 2 K=1 C6 Sens 2 H cal =100% C5 Sens 2 L cal=0% C4 Sens 1 os=0.00 C3 Sens 1 K=45.0 C2 Sens 1 H cal =100% C1 Sens 1 L cal=0%	C9=0 C8 =0.00 C7 =45.0 C6 =0 C5 =100 C4 =0.00 C3 =45.0 C2 =0 C1 =100	0 or 1 Zr limits Zr limits	Load defaults Cell offset. Cell slope. N/A N/A Cell offset. Cell slope. Calibrate high. Calibrate low.
Note:- Sending AxC1=xxx calibrates to xxx, and AxC1 RETURNS the last C1 cal value, but changes nothing. AxC9=1 makes the instrument load HARD CODED DEFAULTS. User will be asked to type 'y' to confirm, or load will be abandoned.					
Ax**D**y	**D**ata (read only)	D6 ADC 3 = 12345cts D5 ADC 2 = 12345cts D4 ADC 1 = 12345cts D3 Sens 3 = N/A D2 Sens 2 = 11.56mV D1 Sens 1 = 11.55mV	D6 = 12345 D5 = 12345 D4 = 12345 D3 =0 D2 =11.56 D1 =11.55		ADC raw counts ADC raw counts ADC raw counts N/A Thermocouple mV Oxygen cell mV
Ax**E**y	**E**rror logs (read only except E9)	E9 Clear Log=0 E8 Calibration=0 E7 Sensor=0 E6 AO=0 E5 Float=0 E4 CRC=0 E3 Other=0 E2 Last=0 E1 Current=0	E9=0 E8=0 E7=0 E6=0 E5 =0 E4 =0 E3 =0 E2 =0 E1 =0	1 to clear logs	Clear all counters Calibration error counter Sensors error counter Analogue output counter Float error counter EEPROM CRC error counter Other error counter Last error code Current error code
Ax**I**y	**I**nput (Read only)	I17 R3 SP=N\A I16 R2 BG=N/A I15 R2 SP=N/A I14 R2 MMW comp=1 I13 R2 RangeT =100 I12 R2 RangeB =0 I11 R2 Os Range=0 I10 R2 K Range=1 I9 R2 Base K =-4.7 I8 R1 BG=N2 I7 R1 SP=O2 I6 R1 MMW comp=1.00 I5 R1 RangeT =100 I4 R1 RangeB =0 I3 R1 Os Range=0.01	I17 =N\A I16 =N/A I15 =N/A I14 =1 I13 =100 I12 =0 I11 =0 I10=0 I9=1 I8 =N2 I7 =O2 I6 =1.000 I5 = 100 I4 = 0 I3 =0.01		

		I2 R1 K Range=1 I1 R1 Base K =-4.7	I2 =1 I1 =-4.7		

Send	Function	Reply (verbose)	Reply (terse)	Limits	Notes
Ax**P**y	**P**arameters.	P9 Terse=0 P8 A2 Mode=1 P7 A2 Hyst=1.0% P6 A2 Level=5.0% P5 A1 Mode=1 P4 A1 Hyst=1.0% P3 A1 Level=5.0% P2 4mA=0% P1 20mA=50%	P9=1 P8 =1 P7 =1.0 P6 =5.0 P5 =1 P4 =1.0 P3 =5.0 P2 =0 P1 =50	0 or 1 0 to 3 1 to 10 (1dp) 0 to 100 As alarm 2 As alarm 2 As alarm 2 0 to 100	1 to set instrument into terse mode – 0 to set verbose 0,1, 2,3 in terse Off, High, Low, status in verbose Alarm hysteresis Alarm trip point As alarm 2 As alarm 2 As alarm 2 Will show 0V or 4mA depending on variant. Zero and FSD limits are interactive.
Send	**Function**	**Reply (verbose)**	**Reply (terse)**	**Limits**	**Notes**
Ax**R**y	**R**eading ** see (8) below*	R5 Comp2=N/A R4 Temp=Normal R3 Alarm2=Normal R2 Alarm1=Normal R1 Conc=5.00%	R5 =0 R4 =1 R3 =0 R2 =0 R1 =5.00	 0 to 2 0 to 2 Instrument range and resolution	 Heater state – see also heater errors. Alarm state – Off, Normal, ALARM or N/A (if not fitted) In terse mode alarm state is 1 in alarm and 0 for all other states Measurand Concentration
Notes on readings:- In over-range condition (110% of instrument span) xxxxx will be '+++++' (e.g. 'R1 Conc= +++++'). Similarly in under-range condition (-5% of instrument span) xxxxx will be '-----'. In the case of a system error R1 will be replaced by the error code e.g. ? 72 ***In verbose mode a brief fault description will be appended***. 'Conc' & '%' are determined by sensor type and unit – see 'U' below. Resolution is application dependant. ***Where a fault is present in the secondary reading it will be indicated by a text description in verbose mode and by a code in the case of Zr units (heater does not return a numeric value in R4) or by -999 or +999 to indicate downscale or upscale failures respectively***.					
Ax**U**y	**U**nit (read only)	U13 Test Flags=0 U12 Factory Flags=0 U11 Output=mA* U10 Sens 2 Ch=1 U9 R2 unit=mV U8 R2 type=T/C U7 R1 Ch=1 U6 R1 unit=% U5 R1 type=Z U4 F/w rev=0.24 U3 F/w p/n=290-6031 U2 S/n = I-700123 U1 Addr=0	U13=0 U12=0 U11=1 U10=1 U9=2 U8 =14 U7 =1 U6 =1 U5 =13 U4 =0.24 U3 =290-6031 U2=I-700123 U1 =0		 Analogue output: 0=4/20mA, 1= 0/1V, 2 = 0/5V, 3=0/20mA Sens 2 ADC chan (9) Sensor Card Address

Error messages

Error messages take the form '? xx' where 'xx' is a numeric code as explained below.

Code	Error	Description
90	Buffer overflow	More than30 characters were received without message terminator (<CR><LF>). Any subsequent characters will begin a new message.
91	Timeout	10 seconds has elapsed since the last character was received without message terminator.
92	Bad opcode	Message was received correctly terminated but not understood (e.g. 'A0Q1<CR><LF>')
93	Bad operand	Message was received correctly terminated and understood but the argument was malformed or out of bounds (e.g. 'A0C2=999.9<CR><LF>').
94	Read only	An attempt was made to write to a read-only parameter (e.g. 'A0R1=1.2<CR><LF>').
97	Initialising	Sensor card is initialising asserted for 10 seconds after a reset or cold start
51-69	Configuration errors	51 Primary cell illegal for this board, 52 Secondary cell illegal for this board,
71-79	CRC error (NVRAM errors)	Error 71 - user parameters CRC error. if this area is restored user calibration etc is LOST. Error 71 will be reported in response to ANY read request until either a calibration is performed or the instrument rebooted. Error 73 & 75 automatically clear themselves so will not be seen. Errors 72, 74 & 76 will be reported in response to any read request and cannot be cleared.

Specific errors

Code	Error	Description
21-22	Calibration errors (20 is OK)	21 K out of bounds during R1 low calibration 22 offset out of bounds during R1 low calibration

Sensor specific errors – report via the reading group (ie R1, R4 or R5)

Code	Error	Description
81	O/C	Sensor open circuit
82	S/C	Sensor short circuit
83	Reversed	Sensor reversed
84	Not Normal	Sensor behaving erratically (Heater Timed Out)
85	Not responding	Drive to sensor on but shows low reading
86	Out of control	Drive to sensor off but shows high reading