



# XZR200

## Oxygen Analyzer

### User's Manual



97337 Issue 2  
November 2013

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## **XZR200**

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## Safety

The manufacturer has designed this equipment to be safe when operated using the procedures detailed in this manual. The user must not use this equipment for any other purpose than that stated. Do not apply values greater than the maximum value stated.

This manual contains operating and safety instructions, which must be followed to ensure the safe operation and to maintain the equipment in a safe condition. The safety instructions are either warnings or cautions issued to protect the user and the equipment from injury or damage. Use qualified personnel and good engineering practice for all procedures in this manual.

## Electrical Safety

The instrument is designed to be completely safe when used with options and accessories supplied by the manufacturer for use with the instrument. The input power supply voltage limit is 24 V  $\pm$ 10%.

## Pressure Safety

The XZR200 is designed to be operated at atmospheric pressures. However, it is possible to measure in the range 0 to 25% O<sub>2</sub> at pressures up to 5 barg (72.5 psig) without damage to the unit. The unit will require calibration at the operating pressure and a separate pressure transducer feeding into your control system may also be required.

## Toxic Materials

The use of hazardous materials in the construction of this instrument has been minimized. During normal operation it is not possible for the user to come into contact with any hazardous substance which might be employed in the construction of the instrument. Care should, however, be exercised during maintenance and the disposal of certain parts.

## Repair and Maintenance

The instrument must be maintained either by the manufacturer or an accredited service agent. Refer to [www.michell.com](http://www.michell.com) for details of Michell Instruments' worldwide offices contact information.

## Calibration

The recommended calibration interval for the XZR200 is between one and three months. This duration may be shorter or longer dependent on installation, application and customer preferences.

## Safety Conformity

This product meets the essential protection requirements of the relevant EU directives.

## Abbreviations

The following abbreviations are used in this manual:

°C	degrees Celsius
°F	degrees Fahrenheit
DC	direct current
EU	European Union
kg	kilogram(s)
l/min	liters per minute
lb	pound
mA	milliampere
max	maximum
min	minute(s)
scfh	standard cubic feet per hour
Td	cycle time to evacuate and re-pressurize the sealed cell
Td averaging	counting x number of cycles and averaging the result
V	Volts
%	percentage
"	inches

## Warnings

The following general warning listed below is applicable to this instrument. It is repeated in the text in the appropriate locations.



**Where this hazard warning symbol appears in the following sections, it is used to indicate areas where potentially hazardous operations need to be carried out.**

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## 1 INTRODUCTION

The XZR200 measures the partial pressure of O<sub>2</sub> utilizing a Zirconium Dioxide (ZrO<sub>2</sub>) sensor cell in Safe Area (general purpose) applications.

This user manual will show you how to measure oxygen using the XZR200 oxygen analyzer.

In the following sections you will learn about:

- Zirconium Dioxide technology
- Analyzer components
- Installation
- Operation
- Calibration

Please read the manual carefully and pay particular attention to any safety warnings and notifications.

**Note: Warnings and items of importance will be marked with bold text.**

### 1.1 Features

- Accurate linear configurable outputs: 4-20mA & 0-10 V DC or RS232
- Selectable output measurement ranges: Standard ranges of 0 to 25% O<sub>2</sub> and 0 to 100% O<sub>2</sub> or fully adjustable via RS232 when configured in 0 to 100% O<sub>2</sub> mode
- Externally triggered automatic or manual calibration
- Calibrated in ambient air (20.7% O<sub>2</sub>) or in any other known O<sub>2</sub> concentration
- Cycling 3.3 V DC logic output allows direct monitoring of the O<sub>2</sub> sensor pump cycle for diagnostic purposes
- Selectable output filtering allows adaptive, fast and dynamic, or slow and stable output
- IP65 die-cast aluminum case with stainless steel probe 210mm (8.27") or 400mm (15.75")

## 1.2 Description

The XZR200 is designed to determine the oxygen concentration in air or inert gas mixtures within a temperature range of -100 to +250°C (-148 to +482°F). The high temperature option increases the maximum allowable sample temperature to +400°C (+752°F). The XZR200 is particularly suitable for measuring oxygen in areas that are not easily accessible, or in closed systems such as ventilation pipes, flues and containers.

The XZR200 can be user-configured to output measuring ranges of 0 to 25% O<sub>2</sub> or 0-100% O<sub>2</sub>. The entire measurement range is linear in both cases. Factory default is 0 to 25% O<sub>2</sub>. When configured for 0 to 100% O<sub>2</sub> the user can also modify the analog output ranges to suit their application. The oxygen concentrations are simultaneously output via 2 output channels (4-20mA and 0 to 10 V DC or RS232 Rx and Tx) - both channels are referenced to the system ground (GND).

The outputs can be configured to either 4-20mA and 0 to 10 V DC or RS232 interface. Prior to shipping, all XZR200's are preconfigured with a measuring range of 0.1% to 25% volume O<sub>2</sub> with linear 4-20mA and 0 to 10 V DC outputs. All settings can be changed by the customer, should the measurement or interface requirements change, by simply altering the position of jumper links on the PCB. The electronics are housed in an IP65 die-cast aluminum housing.

The oxygen sensor is mounted in the tip of the stainless steel probe and is protected by a stainless-steel sintered cap which acts as both a large particulate filter and also as a flame trap.

A digital 3.3 V DC logic output cycles at the same frequency as the electrochemical pumping action of the oxygen sensor during normal operation. This provides a real time sensor health check; if the output ceases to cycle the sensor has entered a start-up or fault state. The digital output is also used during the calibration process to indicate the interface status.

A green on-board LED mirrors the CYCLE output and can be used to visually determine the sensor status or during the calibration process. The red LED indicates the unit has power applied.

The sensor measures the partial pressure of oxygen within the measurement gas and not the oxygen concentration. In order to output an oxygen concentration (%) the XZR200 must be calibrated (more specifically re-referenced) in a known gas concentration, typically normal air. Calibration data is stored on power loss.

The automatic or manual calibration function is user-configurable. Regular calibration removes the effects of application and atmospheric pressure changes and also eliminates any sensor drift that may occur during the first few hundred hours of operation.

## 2 OPERATION

The XZR200 is designed as a fit and forget device. Once configured, installed and all electrical connections made, there are no further operating instructions required. Only routine inspection and calibration of the unit is required. The inspection is more a preventative measure to ensure the surrounding environment or any other factor is not damaging or interfering with the performance of the analyzer.

### 2.1 Configuration

The XZR200 may be reconfigured at any time by adjusting the position of the header pin jumper links on the interface PCB.



**Prior to re-configuration the unit MUST be powered down. The jumper links MUST also be re-positioned correctly and in the correct orientation.**

**Failure to adhere to the above could result in product damage. Products damaged due to incorrect configurations will not be covered under warranty.**

1. Power down the analyzer
2. Remove the lid using a Phillips (cross head) screwdriver.
3. Adjust the position of the jumper links to the desired configuration.

The diagrams below and show the correct positioning for each user-configurable option. Thin-nosed pliers should be used to remove and replace the jumper links. Ensure the jumper links are correctly seated before reapplying the power.

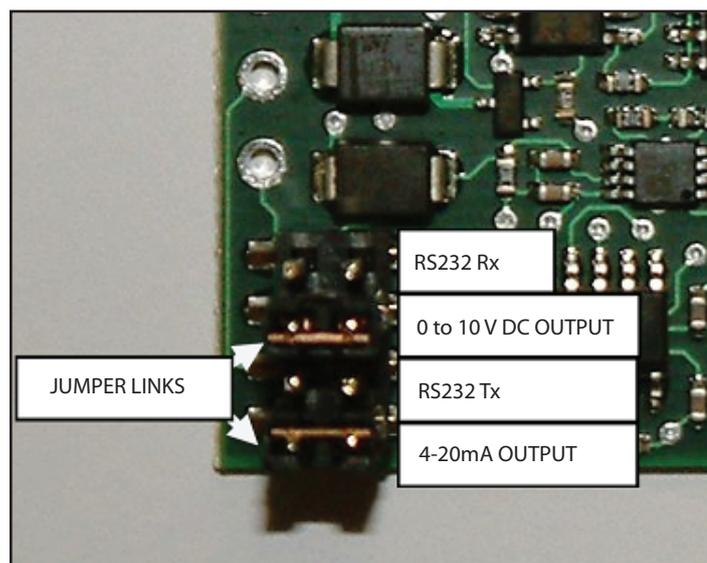


Figure 1 *Jumper Configuration for Output Selection*

**NOTE: Each jumper link must be placed in one of the two positions.**

When selecting the output, you must choose either 4-20mA and 0 to 10 V DC or RS232 Tx and Rx. Ensure the jumper links are always inserted horizontally between 2 adjacent pins.

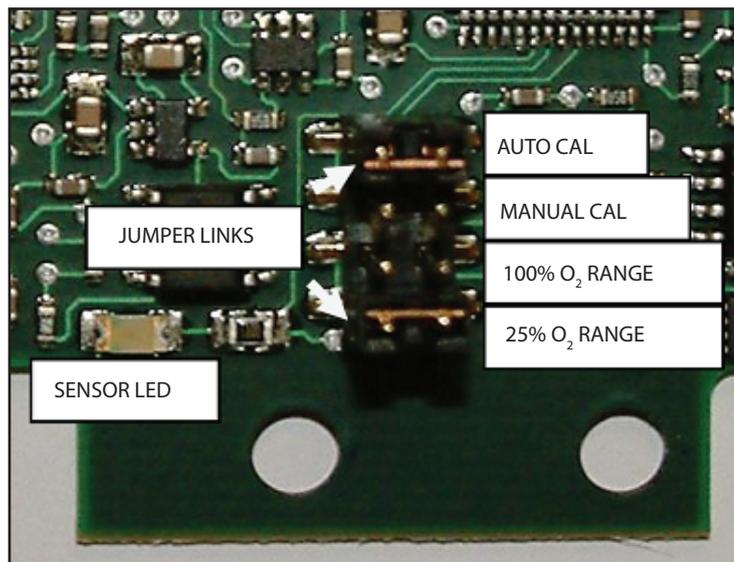


Figure 2 *Jumper Configuration for Calibration Type & Range Selection*

## 2.2 Initial Sensor Drift and Active Burn-In

**NOTE: In the first 200 hours the sensor output can drift by up to  $\pm 3\%$ .**

This is due to a number of factors including:

- impurities in the Zirconium Dioxide migrating to the surface of the platinum electrode bond which alters the catalytic properties.
- heater coil ageing.
- the internal stainless steel surface of the cap becoming less reflective due to thermal oxidation.

Regular calibration removes the effect of initial sensor drift as the sensor output is constantly re-referenced against the known calibration gas. However, if regular calibration is not possible and the output is required to have stabilized prior to use in the application then it may be necessary to actively burn-in the sensor.

Active burn-in involves operating the sensor normally in a controlled atmosphere where the exact PPO<sub>2</sub> is known. If this is normal air then all weather data must be recorded and the PPO<sub>2</sub> calculated.

The level of stability required will be dependent on the application specifications. However, in general the output can be considered stable when the value has varied by less than  $\pm 0.2\%$  of reading in the previous 48 hours.

When performing an active burn-in, measurements should be taken at regular intervals and the environmental temperature should also be kept constant to negate any temperature dependence the sensor output may exhibit.

## 2.3 XZR200 Variations

The XZR200 will be set-up as one of the following variations (as per customer order):

XZR200-B1-C1	XZR200, standard temperature up to +250°C (+482°F) 210mm (8.27") probe
XZR200-B1-C2	XZR200, standard temperature up to +250°C (+482°F) 400mm (15.74") probe
XZR200-B2-C1	XZR200, high temperature up to +400°C (+752°F) 210mm (8.27") probe
XZR200-B2-C2	XZR200, high temperature up to +400°C (+752°F) 400mm (15.74") probe

## 2.4 Life Span of the Analyzer

Dependent on the application, the XZR200 sensor will have a variable lifespan. In ambient temperatures with inert gases, the sensor should last approximately 7 years.

For combustion processes the following guide should be used:

Natural gas	Approximately 5 to 7 years
Biogas	Approximately 3 to 4 years
Biomass	Approximately 2 years
Coal and Oil	Approximately 1 to 2 years



**If there is zero oxygen in the sample, the sensor will still try to pump O<sub>2</sub> within the ZrO<sub>2</sub> and this will, in time, damage the ZrO<sub>2</sub> and degrade its performance. It is, therefore, imperative that the sensor is not used for prolonged periods in very low oxygen environments (0.1% O<sub>2</sub>), especially in reducing atmospheres (an atmosphere in which there is little free oxygen and oxygen is consumed).**

3 INSTALLATION



**When installing the sensor do not use any lubricants or grease which may contain silicone.**



**The sensor is located in the tip of the probe and is heated to 700°C (1292°F).**

**Do NOT touch the probe tip with bare hands as this will cause damage to skin.**

3.1 Mounting and Orientation



**The XZR200 should be grounded (earthed) via the probe as well as through the cable.**

When using the XZR200 in a combustion process the diagram below shows the correct mounting and orientation. The downward angle of the probe tip will protect the sensor from dust settling or moisture sitting in the tip and damaging the sensor.

A 12mm fitting with a retaining nut that can be welded to the process and fix the probe in position. A suitable O-ring should be used to ensure a good seal.

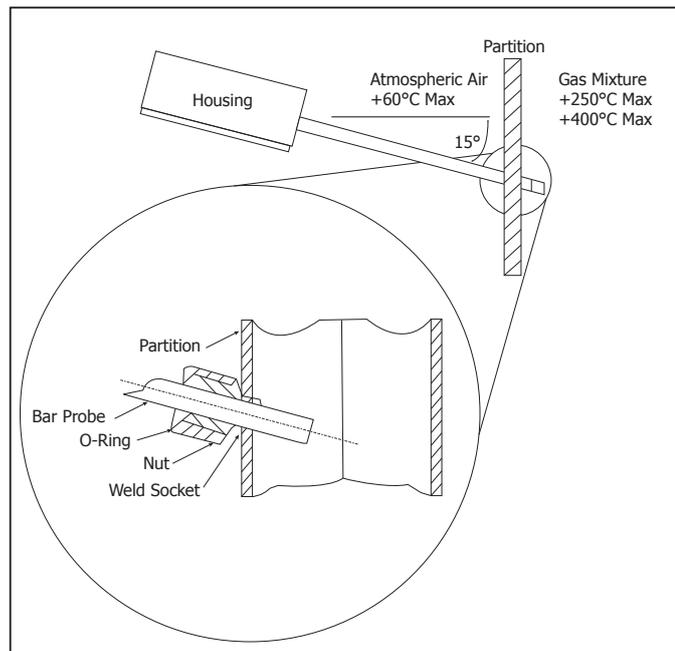
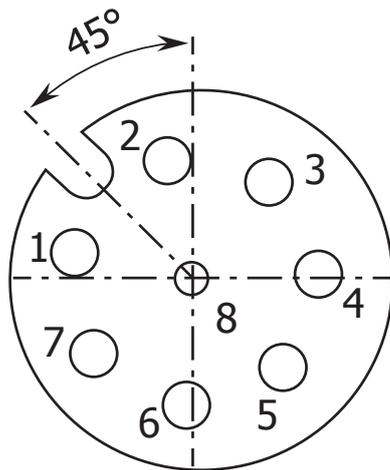


Figure 3 Mounting and Orientation

### 3.1.1 Ambient Monitoring

When used for ambient monitoring or confined spaces, there are two holes on the rear of the electronics case that can be utilized for mounting (see Dimensions in Appendix A). If placed tight against a wall or surface, a heat shield may be required to protect the surface from being damaged.

## 3.2 Electrical Connections



Pin Number	Description
1	24 V DC $\pm$ 10%
2	NC
3	0 to 10 V DC / RS232 Rx
4	4-20mA / RS232 Tx
5	Cycle
6	Calibrate
7	GND (0 V DC)
8	NC
Connector Body	Housing/Probe Earth

Figure 4 *Electrical Connections*

Housing connector: 99 3481 578 08

Mating connector: 713 99 1486 812 08  
(mating connector supplied loose with each product)

Output pins 3 and 4 are both referenced to the supply GND (pin 7). Due to high current flow in the supply GND - when monitoring the 0 to 10 V DC output (pin 3) it is recommended that a separate GND wire for the measurement system is taken from pin 7. This removes errors due to voltage drops in the power supply connections.

### 3.3 System Block Diagram

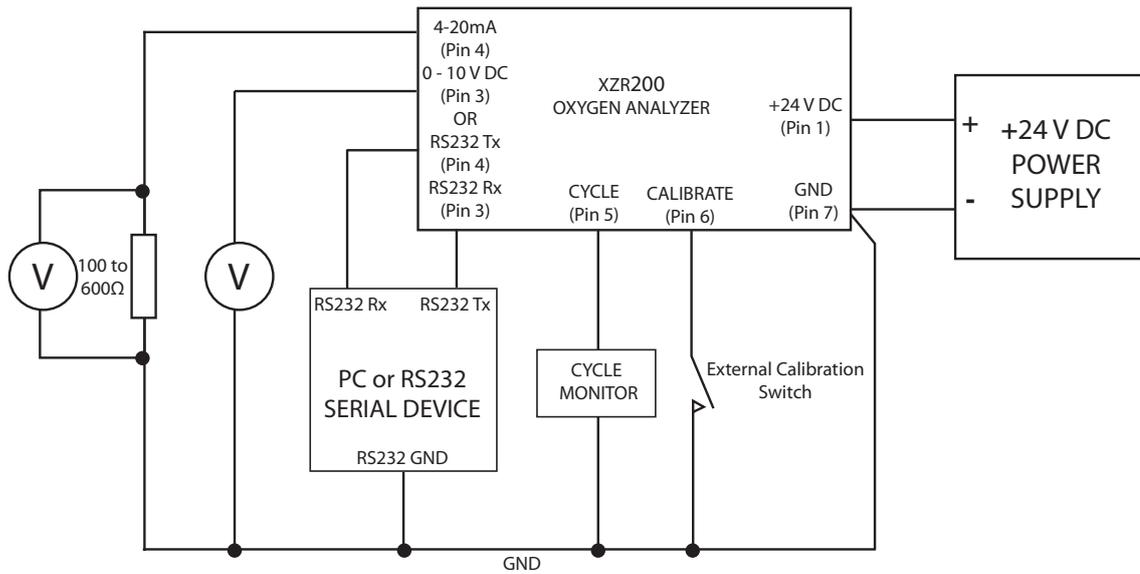


Figure 5 System Block Diagram

### 3.4 RS232 Communication Settings

When connecting the XZR200 via the RS232 connections, ensure Tx goes to Rx of the PC and Rx goes to Tx of the PC.

The XZR200 communicates via standard COM port settings that are default on most PC's and many other RS232 compatible devices. If, however, communication problems are occurring, the settings below can be used to configure the PC or device COM Port.

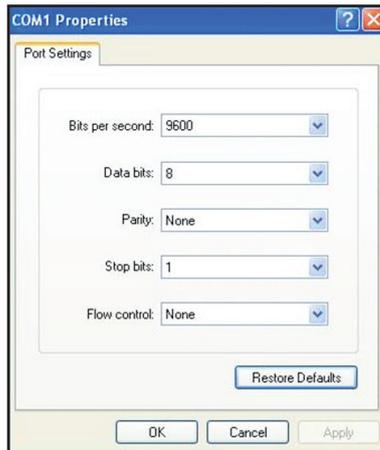


Figure 6 COM Port Settings

### 3.5 RS232 Operation

With the RS232 outputs connected to a PC or any other RS232 compatible device the user has the ability to access two modes of operation, continuous data streaming and the menu screens.

Programs for communicating via PC serial RS232 are readily available.

### 3.6 RS232 User-Configurable Options

#### 3.6.1 Menu Screens

If the XZR200 receives an **ENTER** command from the connected PC or device, it automatically enters the password screen and stops outputting O<sub>2</sub> % and Td values. After the correct password is input followed by the **ENTER** key, the menu screens are accessed. The menu screens are primarily for diagnostics and information, although there are user-configurable options that may be changed. These are: the amount of output filtering (averaging), the automatic O<sub>2</sub> calibration %, and the analog output ranges. All three processes are further described below. The menu access password may also be changed by the user, as shown below.

#### 3.6.2 Changing the Menu Access Password

The password is factory set to 'default'. However this may be changed to a user specific password.

1. Connect the XZR200 via the RS232 interface to the PC.
2. Press **ENTER** then enter your current security password.
3. Press **ENTER** to access the menu screen.
4. In the Configuration Menu (menu 2) enter '3' to access the password menu screen.
5. Enter the new password then press **ENTER** to save.

The new password is now stored in memory and is retained on power loss.

Pressing **ESC** returns the screen to the previous menu.

### 3.6.3 Variable Output Filtering (Td Averaging)

The XZR200 is factory set to use adaptive output filtering to give an optimum balance between output stability and response to oxygen changes. However, this balance may be altered by the customer to suit the needs of the application.

1. Connect the analyzer via the RS232 interface to the PC. See Section 2.1 on Configuration.
2. Press **ENTER** then enter your security password. Press **ENTER** to access the menu screen.
3. In the Configuration Menu (menu 2) enter the Td average screen (Option 2 - Enter Td Averaging).
4. The number entered should be between 0 and 200. 0 for adaptive filtering (recommended), 1 for very fast and dynamic output response but relatively unstable, to 200 for an extremely stable output but very slow response to oxygen changes.
5. Press **ENTER** to save.

The new averaging value is now stored in memory. This value is retained on power loss.

Td output by the XZR200 is proportional to the partial pressure of oxygen (PPO<sub>2</sub>) and the typical value of Td per mbar of PPO<sub>2</sub> is 1.05ms ±15%.

For example if we have 20.7% oxygen in 1000mbar barometric pressure the PPO<sub>2</sub> value would be 207mbar. This equates to a typical Td of 207\*1.05=217.5ms.

To convert the XZR200 Td output back to ms the number must be multiplied by 0.000048 which is the clock period of the microprocessor in seconds.

So for the example above a Td value of 217.5ms would be output from the XZR200 as,  $0.2175/0.000048 = 4531$ .

### 3.6.4 Changing the Automatic Calibration Value

The system is factory set to automatically calibrate to 20.7% O<sub>2</sub> to allow simple calibration in normal air. The auto calibration value is factory set to 20.7% to take into account average humidity in the atmosphere. If a calibration with a gas of a different known oxygen concentration is required, then the factory set value may be changed via the RS232 interface.

1. Connect the XZR200 via the RS232 interface to the PC. See Section 2.1 on Configuration.
2. Press **ENTER** then enter your security password. Press **ENTER** to access the menu screen.
3. In the Configuration Menu (menu 2) enter the auto calibration value screen (Option 1 - Enter Auto Calib).
4. The number entered should be the oxygen concentration (%) of the calibration gas to 2 decimal places. Press **ENTER** to save.

The new Automatic Calibration value is now stored in memory. This value is retained on power loss.

If calibration is required with a different gas of known O<sub>2</sub> concentration, and access to the RS232 menus with a PC is not available in order to change the calibration percentage, a manual calibration must be performed.

### 3.6.5 Adjusting the Minimum and Maximum Ranges of the Analog Outputs (4-20mA and 0 to 10 V DC)

The XZR200 is factory default to output a range of 0-25% O<sub>2</sub> via its two analog outputs.

This range can be expanded to 0 to 100% O<sub>2</sub> as described in Section 2.1. When the unit is reconfigured to output 0 to 100% O<sub>2</sub> the user also has the option to fully customize the output ranges via RS232. This is extremely useful in applications where the O<sub>2</sub> variation is within a narrow band as it allows the analog outputs to be tailored to this limited range.

1. Ensure the XZR200 is configured for 0 to 100% and RS232 operation. See Section 2.1 on Configuration.
2. Connect the XZR200 via the RS232 interface to the PC.
3. Press **ENTER** then enter your security password. Press **ENTER** to access the menu screen.
4. In the Configuration Menu (menu 2) enter the maximum range screen (Option 3 - Enter O<sub>2</sub> Max Range).
5. The number entered should be between 1.00 and 100.00 to represent the maximum output range. The number must also be greater than the saved minimum range.
6. Press **ENTER** to save and **ESC** to return to the Configuration Menu.
7. Enter the minimum range screen (Option 4 - Enter O<sub>2</sub> Min Range).
8. The number entered should be between 0.00 and 99.00 to represent the minimum output range. The number must also be less than the saved maximum range.
9. Press **ENTER** to save.

The new ranges are now stored in memory and are retained on power loss.

An example of changing the min and max output ranges would be in a normal air atmosphere where the O<sub>2</sub> range is between 20 to 21%. The user could set the minimum output range to 19% and the maximum output range to 22% and the outputs would vary linearly in between. The min and max ranges lock out the outputs at the set limits - so 19% O<sub>2</sub> or lower would set the analog outputs to 0 V DC / 4mA and 22% O<sub>2</sub> or higher would set the analog outputs to 10 V DC / 20mA.

**NOTE: The min and max range adjustment does not apply to the RS232 output and is overruled if the unit is reconfigured for 0 to 25% operation.**

### 3.7 Continuous Data Streaming

On power up, after the initial 60 seconds warm up period, the XZR200 will automatically begin to output the measured O<sub>2</sub> concentration and sensor Td as both an averaged and raw value. The sensor Td value is the measure of the partial pressure of oxygen in the measurement gas. The O<sub>2</sub> concentration (%) is the Td value scaled by the stored calibration value.

The averaged values give a stable (smooth) output while the raw un-averaged values allow the user to detect sudden oxygen changes. The averaged value is the measurement output on both the 4-20mA and 0 to 10 V DC outputs. The user can alter the averaging setting to suit the application requirements.

**NOTE: To stop or restart the data streaming - the command 's' (lower or upper case) should be sent to the unit. Data streaming automatically ceases during calibration.**

## 4 CALIBRATION

The XZR200 will require routine calibration determined by the application, installation and user preferences. The analyzer can be configured for manual or automatic calibration by changing the jumper on the board. Calibration is achieved by connecting the calibration input to GND and monitoring the status of the digital cycle output or by visually monitoring the on-board green LED. During the calibration process the output will either automatically calibrate to a fixed reference or can be manually calibrated to any output by way of a PCB mounted potentiometer.

The fixed reference is factory set to 20.7% O<sub>2</sub> for calibration in normal air though this value may be altered via the RS232 interface for calibration with a reference gas of any known oxygen concentration.

### 4.1 Automatic Calibration

Ensure the XZR200 is configured for automatic calibration. See Section 2.1 on Configuration.

1. Place the sensor probe in the calibration gas, typically normal air.
2. Allow the output to stabilize for at least 5 minutes. Allow 10 minutes if powering from cold.
3. Apply GND to the CALIBRATE input (PIN 3) for a minimum of 12 seconds. During the 12 seconds, the CYCLE output (PIN 4) and the green LED will go high/on, blink rapidly, go high/on, go low/off then return to cycling normally to indicate normal operation has resumed. At this point remove GND from PIN 3.
4. The output will now track to the correct value for the calibration gas.

Calibration is complete. Calibration values are retained on power loss.

### 4.2 Manual Calibration

Ensure the XZR200 is configured for manual calibration. See Section 2.1 on Configuration.

1. Place the sensor probe in the calibration gas, typically normal air.
2. Allow the output to stabilize for at least 5 minutes. Allow 10 minutes if powering from cold.
3. Apply GND to the CALIBRATE input (PIN 3) for a minimum of 5 seconds or until the CYCLE output and green LED blink at a steady 1Hz. Remove GND from PIN 3. Manual calibration is now initialized.
4. Adjust the MANUAL CAL POT until the output equals the correct value of the calibration gas concentration.
5. Re-apply GND to PIN 3 for a minimum of 5 seconds. During the 5 seconds the CYCLE output/LED will blink rapidly, go high/on, go low/off then return to cycling normally to indicate normal operation has resumed. At this point remove GND from PIN 3.
6. The output will now track to the correct value for the calibration gas.

Calibration is complete. Calibration values are retained on power loss.

## 5 GOOD MEASUREMENT PRACTICE

There are no user-serviceable parts in the XZR200. In the event of a repair or warranty case, please return the unit, suitably packaged with a decontamination certificate, to Michell's Service Department.

### 5.1 Error Conditions

If the oxygen sensor is damaged, the XZR200 will highlight this by blinking the CYCLE output (pin 4) and green LED in 3 short blinks, 1 long blink pattern or continuously OFF. An error code is also displayed on the RS232 output and the analog outputs will go to 4mA and 0 V.

### 5.2 Sensor Operating Tips

To get the best performance from the XZR200 analyzer it is important that the oxygen probe is installed and maintained in the correct manner. The following are useful sensor operating tips and list of gases & materials that must be avoided to ensure a long sensor life.

#### 5.2.1 Operating the Sensor in Aggressive Humid Environments

When operating the sensor in warm, humid environments it is important the sensor remains at a higher temperature than its surroundings, especially if there are corrosive components in the measurement gas. During operation this is not a problem due to the 700°C (1292°F) generated by the heater. However, when the sensor or application is being powered down, the sensor heater must be the last thing to be turned off after the temperature of the surroundings have suitably cooled. Ideally the sensor should be left powered at all times in very humid environments.

Failure to adhere to the above will result in condensation forming on the heater and sensing cell (as these will be the first components to cool due to their connections to the outside world). When the sensor is re-powered the condensation will evaporate, leaving behind corrosive salts which very quickly destroy the heater and cell as illustrated below. Note how the sensor's external metalwork looks completely normal.



Figure 7 *Sensor Damage*

### 5.2.2 Protecting from Water Droplets

In environments where falling water droplets are likely, the sensor should be protected from water falling directly onto the very hot sensor cap as this can cause massive temperature shocks to the cell and heater. Popular methods include a hood over the sensor cap or for the sensor to be mounted in a larger diameter cylinder.

At a very minimum the sensor cap should be angled downwards in the application as this will deflect any falling moisture and prevent the sensor cap from filling with water (see Section 3, Installation).

### 5.2.3 Cross Sensitivity With Other Gases

Gases or chemicals that will have an influence on the life of the sensor or on the measuring results are:

#### 1. Combustible Gases

Small amounts of combustible gases will be burned at the hot Platinum electrode surfaces or Al<sub>2</sub>O<sub>3</sub> filters of the sensor. In general, combustion will be stoichiometric as long as enough oxygen is available. The sensor will measure the residual oxygen pressure which leads to a measurement error (low oxygen reading). The sensor is not recommended for use in applications where there are large amounts of combustible gases present and an accurate O<sub>2</sub> measurement is required.

Gases tested:

- H<sub>2</sub> (Hydrogen) up to 2%; stoichiometric combustion
- CO (Carbon Monoxide) up to 2%; stoichiometric combustion
- CH<sub>4</sub> (Methane) up to 2.5%; stoichiometric combustion
- NH<sub>3</sub> (Ammonia) up to 1500 ppm; stoichiometric combustion

#### 2. Heavy Metals

Vapors of metals like Zn (Zinc), Cd (Cadmium), Pb (Lead) and Bi (Bismuth) will have an effect on the catalytic properties of the Pt- electrodes. Exposure to these metal vapors must be avoided.

#### 3. Halogen and Sulphur Compounds

Small amounts (< 100ppm) of Halogens and/or Sulphur compounds have no effect on the performance of the oxygen sensor. Higher amounts of these gases will, in time, cause readout problems or, especially in condensing atmospheres, corrosion of sensor parts. These gases often outgas from plastic housings and tubes when hot.

Investigated gases were:

- Halogens, F<sub>2</sub> (Flourine), Cl<sub>2</sub> (Chlorine)
- HCL (Hydrogen Chloride), HF (Hydrogen Fluoride)
- SO<sub>2</sub> (Sulphur Dioxide)
- H<sub>2</sub>S (Hydrogen Sulphide)
- Freons
- CS<sub>2</sub> (Carbon Disulfide)

#### 4. Reducing Atmospheres

Long time exposure to reducing atmospheres may, in time, impair the catalytic effect of the Pt-electrodes and has to be avoided. Reducing atmospheres are defined as an atmosphere with very little free oxygen and where combustible gases are present. In this type of atmosphere oxygen is consumed as the combustible gases are burned.

#### 5. Other

Fine dust (Carbon parts/soot) might cause clogging of the porous stainless steel filter and may have an effect on the response of the sensor to oxygen changes. Heavy shocks or vibrations may alter sensor properties resulting in the need for a recalibration.

#### 5.2.4 Using the Sensor with Silicones

The XZR200 oxygen sensor, like all other Zirconium Dioxide sensors, will be damaged by silicon presence in the measurement gas. Vapors (organic silicone compounds) of RTV rubbers and sealants are widely used in many applications. These materials, which are often applied as a liquid or gel, still release silicone vapors into the surrounding atmosphere even after they have cured. When these vapors reach the sensor the organic part of the compound will be burned at hot sensor parts, leaving behind a very fine silicon-dioxide ( $\text{SiO}_2$ ). This  $\text{SiO}_2$  completely blocks the pores and active parts of the electrodes.

If silicon cannot be avoided in the application we advise using high quality, high temperature cured materials which do not release silicone vapor when subsequently heated.



**When installing the sensor do not use any lubricants or grease which may contain silicon.**

# Appendix A

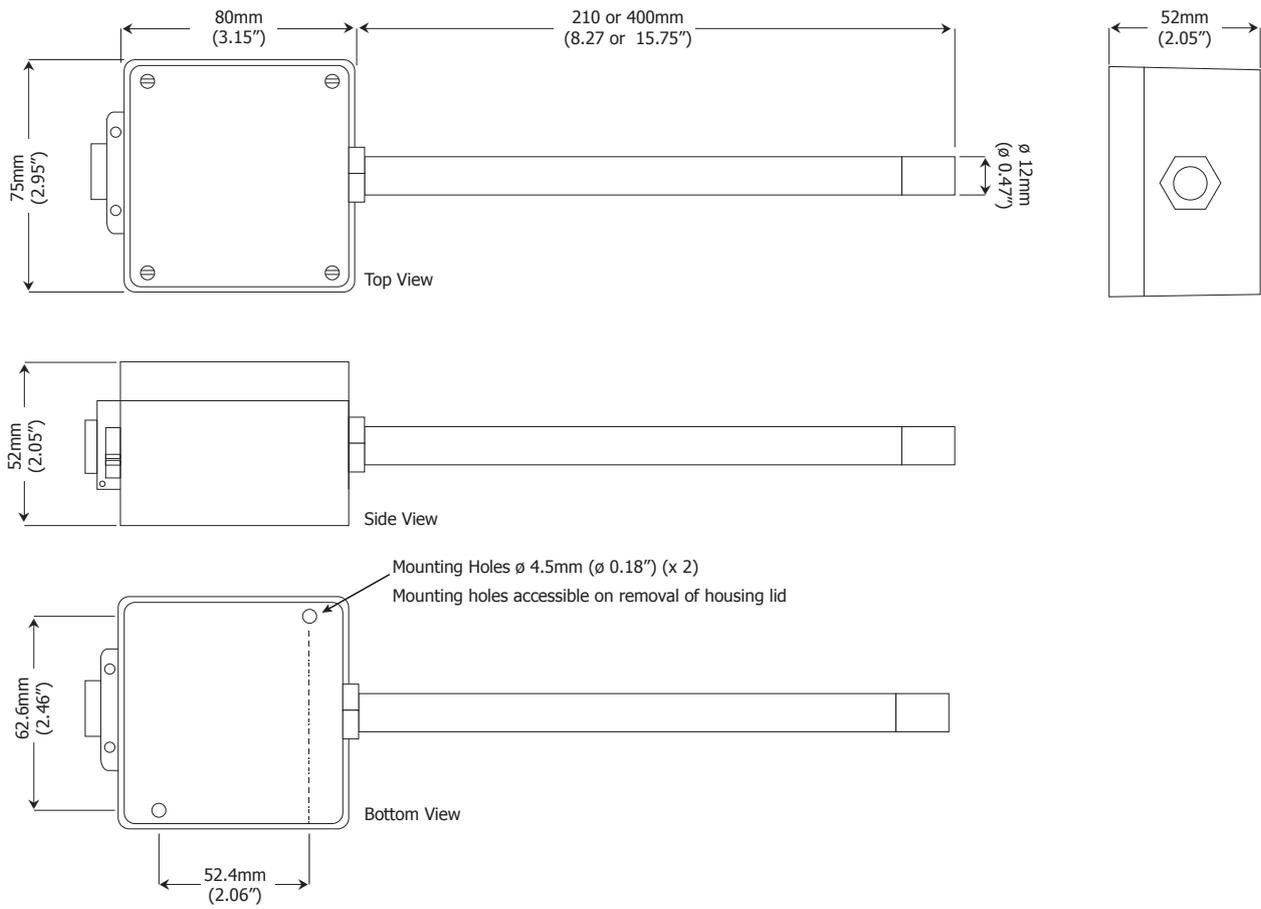
## Technical Specifications

## Appendix A Technical Specifications

<b>Performance</b>	
Measurement Technology	Zirconium Dioxide
Gas	Oxygen
Measurement Range	0 to 25% or 0 to 100%
Output Resolution	0.01 V, 0.01 mA or 0.01% O <sub>2</sub>
Accuracy (0 to 25%)	< 0.5% O <sub>2</sub>
Accuracy (0 to 100%)	< 1% O <sub>2</sub>
Response Time (T90) with High Speed Response (HSR) enabled	< 20 seconds
Repeatability	< 0.5%
Sample Flow Rate	0 to 100 l/min (0 to 212 scfh)
Sample Flow Effect (calibrated @ 0.5 l/min)	±0.1% O <sub>2</sub> (0 to 1 l/min)
Sample Pressure	Atmospheric*
Sample Temperature	+250°C or +400°C (+482°F or +752°F)
Sample Cell temperature	+700°C (+1292°F)
Background Gas	N <sub>2</sub> , CO <sub>2</sub> , Ar or He
<b>Electrical Specifications</b>	
Power Supply	24 V DC, ±10%
Analog Outputs	4-20 mA and 0 to 10 V DC
Output Ranges	0 to 25% or 0 to 100%
Digital Communications	RS232 (not available if 4-20 mA output selected)
<b>Operating Conditions</b>	
Ambient Temperature	-10 to +85°C (14 to +185°F)
<b>Mechanical Specifications</b>	
Warm Up Time	Approximately 10 minutes
Stabilization Time	Included in the above
Dimensions	52 x 75 x 80mm (2.05 x 2.95 x 3.15") (h x w x d) excluding probe
Probe Dimensions	210 or 400mm (length) ø 12mm (8.27 or 15.75" (length) ø 0.47")
Weight	< 0.5kg (< 1.1lb)
Wetted Materials	Stainless steel
Process Connection	12mm Swagelok® connector
Ingress Protection	IP65
Housing Material	Waterproof die-cast aluminum housing

\* The XZR200 is designed to be operated at atmospheric pressures. However, it is possible to measure in the range 0 to 25% O<sub>2</sub> at pressures up to 5 barg (72.5 psig) without damage to the unit. The unit will require calibration at the operating pressure and a separate pressure transducer feeding into the control system may be required.

Dimensions



# Appendix B

## Theory of Operation

## Appendix B Theory of Operation

The sensor employs a well proven, small Zirconium Dioxide based element at its heart that does not require a reference gas. This removes limitations in the environments in which the sensor can be operated with high temperatures, humidity and oxygen pressures all possible.

### Background Physics:

The partial pressure is defined as the pressure of a single gas component in a mixture of gases. It corresponds to the total pressure which the single gas component would exert if it alone occupied the whole volume.

### Dalton's Law:

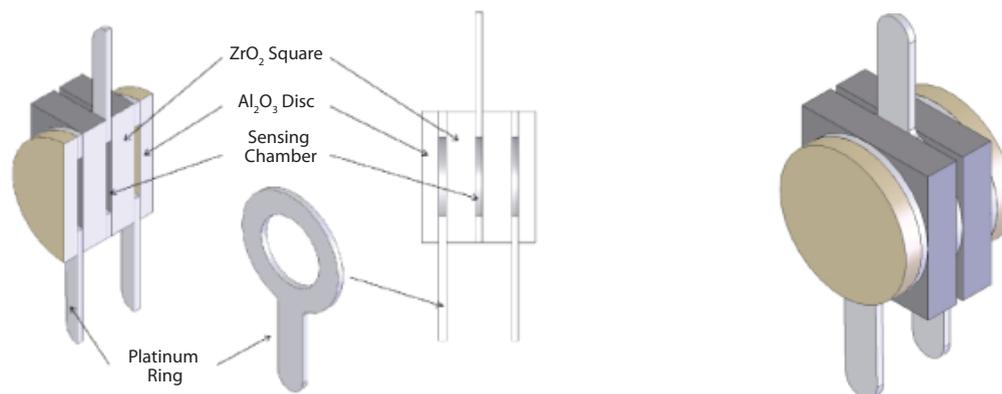
The total pressure ( $p_{total}$ ) of a mixture of ideal gases is equal to the sum of the partial pressures ( $p_i$ ) of the individual gases in that mixture.

$$P_{total} = \sum_{i=1}^k P_i$$

From the equation above it can be derived that the ratio of the number of particles ( $n_i$ ) of an individual gas component to the total number of particles ( $n_{total}$ ) of the gas mixture equals the ratio of the partial pressure ( $p_i$ ) of the individual gas component to the total pressure ( $p_{total}$ ) of the gas mixture.

$$\frac{n_i}{n_{total}} = \frac{P_i}{P_{total}}$$

$n_i$	Number of particles in gas i
$n_{total}$	Total number of particles
$p_i$	Partial pressure of gas i
$p_{total}$	Total pressure

**Sensor Function:**

At the core of the XZR200 oxygen analyzer is a cell consisting of two Zirconium Dioxide ( $ZrO_2$ ) squares coated with a thin porous layer of platinum which serve as electrodes. The platinum electrodes provide the catalyst necessary for the measured oxygen to dissociate, allowing the oxygen ions to be transported through the  $ZrO_2$ .

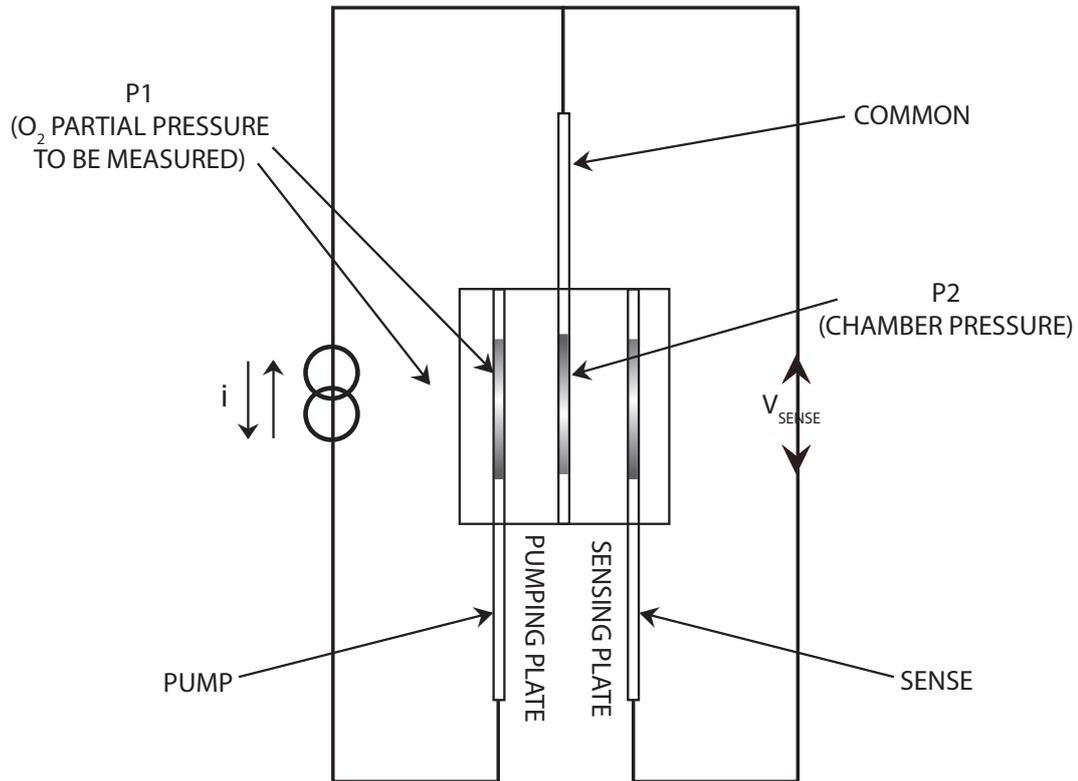
The two  $ZrO_2$  squares are separated by a platinum ring which forms a hermetically sealed sensing chamber. At the outer surfaces there are two further platinum rings which, along with a center platinum ring, provide the electrical connections to the cell.

Two outer alumina ( $Al_2O_3$ ) discs filter and prevent any particulate matter from entering the sensor and also remove any unburnt gases. This prevents contamination of the cell which may lead to unstable measurement readings. The above figure shows a cross-section of the sensing cell with all the major components highlighted.

A heater coil which produces the necessary  $700^\circ C$  ( $1292^\circ F$ ) required for operation, surrounds the sample cell. Both are housed within a porous stainless steel cap to filter larger particles and dust. The filter cap also protects the sensor from mechanical damage.

**Pumping Plate:**

The first  $ZrO_2$  square works as an electrochemical oxygen pump, evacuating or re-pressurising the hermetically sealed chamber. Depending on the direction of the reversible DC constant current source the oxygen ions move through the plate from one electrode to the other. This in turn changes the oxygen concentration and therefore the pressure ( $P_2$ ) inside the chamber. As we only evacuate then re-pressurize the chamber using the gas around the sensor, the pressure inside the chamber is always less than the ambient pressure outside the chamber. The electrical connections to the cell are shown in the figure below.



### Sensing Plate:

A difference in oxygen pressure across the second  $ZrO_2$  square generates a Nernst voltage which is logarithmically proportional to the ratio of the oxygen ion concentrations (see Nernst Voltage). As the pressure inside the chamber ( $P_2$ ) is always kept less than the pressure outside of the chamber ( $P_1$ ), the voltage at SENSE with respect to the common is always positive.

This voltage is sensed and compared with two reference voltages and every time either of these two references is reached, the direction of the constant current source is reversed. When the  $PPO_2$  is high, it takes longer to reach the pump reversal voltages than it does in a low  $PPO_2$  atmosphere. This is because a greater number of oxygen ions are required to be pumped in order to create the same ratio-metric pressure difference across the sensing disc.

### Nernst Voltage:

Two different ion concentrations on either side of an electrolyte generate an electrical potential known as the Nernst Voltage. This voltage is proportional to the natural logarithm of the ratio of the two different ion concentrations.

$$\Delta V = - \frac{k_B T}{e_0} \cdot \ln \left( \frac{c_1}{c_2} \right)$$

$k_B$	Boltzmann constant ( $k_B = 1.3 \times 10^{-23} \text{J/K}$ )
$T$	Temperature in K
$e_0$	Elementary charge ( $e_0 = 1.602 \times 10^{-19} \text{C}$ )
$c_i$	Ion concentration in mol/kg

# Appendix C

## EC Declaration of Conformity

## Appendix C EC Declaration of Conformity

## EC Declaration of Conformity



Manufacturer: **Michell Instruments Limited**  
48 Lancaster Way Business Park  
Ely, Cambridgeshire  
CB6 3NW. UK.



We declare under our sole responsibility that the product:

### **XZR200 Oxygen Analyser**

complies with all the essential requirements of the EC directives listed below.

**2004/108/EC**                      **EMC Directive**

Using the standards:

**EN61326-1:2006**                      **Electrical equipment for measurement, control and laboratory use – EMC requirements –Class B (emissions) and Industrial Locations (immunity).**

and has been designed to be in conformance with the relevant sections of the following standards or other normative documents.

EN61010-1:2001                      Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements

A handwritten signature in blue ink, appearing to read 'Andrew M.V. Stokes'.

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Andrew M.V. Stokes, Technical Director

Date of Issue: May 2013

# Appendix D

## Quality, Recycling & Warranty Information

## Appendix D Quality, Recycling & Warranty Information

### D.1 Pressure Equipment Directive (PED) 97/23/EC

The above Directive has been implemented in United Kingdom Law by the Pressure Equipment Regulations 1999.

The Regulations require that all pressure equipment and assemblies within the scope of the Pressure Equipment Directive must be safe when placed on the market or put into service.

Michell Instruments' products have been assessed and, as referenced against the Classification Charts detailed in Annex II of the Directive, do not fall into the requirements for CE marking compliance with the Pressure Equipment Directive.

Article 3, paragraph 3 states that any product containing a pressurized fluid that does not qualify for compliance should, nevertheless, be constructed with Sound Engineering Practice (SEP).

Michell Instruments attests here that its products have been designed, manufactured & tested to assure safe operation, and in accordance with Sound Engineering Practices.

### D.2 Recycling Policy



Michell Instruments is concerned with the protection of the environment. It is our commitment to reduce and eliminate from our operations, wherever possible, the use of substances which may be harmful to the environment. Similarly, we are increasingly using recyclable and/or recycled material in our business and products wherever it is practical to do so.

To protect natural resources and to promote material reuse, please separate batteries from other types of waste and recycle responsibly. If batteries are not properly disposed of, these substances can cause harm to human health and the environment.

The product that you have purchased may contain recyclable and/or recycled parts and we will be happy to provide you with information on these components if required. For further information please see the following sections.

### D.3 WEEE Compliance

#### Directive 2012/19/EU 4 July 2012 on Waste Electronic and Electrical Equipment (WEEE)

The Waste Electronic and Electrical Equipment (WEEE) Directive places rules upon European manufacturers of electrical and electronic equipment. The directives' aim is to reduce the impact that electronic devices have on the environment.

Michell Instruments is in full compliance with the WEEE Directive and is registered with an approved recycler (Registration No. WEE/JB0235YW) and treats the requirement of the directive and the protection of the environment with the utmost importance. All Michell Instruments' products are appropriately marked indicating their requirement for recycling.

It may be required to return certain instruments for treatment at the end of their working life.

Feb 2013

## D.4 RoHS2 Compliance

### Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011

The Restriction of Hazardous Substances (RoHS) Directive places rules upon European manufacturers of electrical and electronic equipment. The directives' aim is to reduce the impact that electronic devices have on the environment.

According to the EC Directive 2002/95/EC, Michell Instruments' products qualify as Category 9, Control and Monitoring Equipment. Under the 2002/95/EC Directive, Category 9 products are exempt from compliance with the Directive.

However, the careful design of all Michell Instruments' products takes into consideration the requirements of the Directive and, wherever possible, compliance is achieved. All future products will be developed entirely using compliant materials. Furthermore, Michell Instruments is taking active steps to remove non-compliant materials and components from existing products wherever these may occur. Presently, none of the non-compliant materials are known to occur in Michell Instruments' products.

The new Directive 2011/65/EU (RoHS2) entered into force on 21 July 2011 and required all Member States to transpose the provisions into their respective national laws by 2 January 2013.

Under the provisions of the RoHS2 EU Directive 2011/65/EU (Article 3, [24]) defines 'Control and Monitoring Equipment' specifically as 'monitoring and control instruments designed exclusively for industrial or professional use'.

RoHS2 EU Directive 2011/65/EU states the closing date for compliance of any Control and Monitoring Equipment product sold into the EU market place as 22nd July 2017.

However, the careful design policy of all Michell Instruments' products continues to attain compliance in the shortest practical timescales and strives to ensure that less than 0.1% of total mass per product, of all non-compliant materials, appear within them. Michell Instruments continues to monitor suppliers and material sources to ensure that compliance of goods provided is maintained.

January 2013

## D.5 Warranty

Unless otherwise agreed, the Supplier warrants that, as from the date of delivery for a period of 12 months, the goods and all their component parts, where applicable, are free from any defects in design, workmanship, construction or materials.

The Supplier warrants that the services undertaken shall be performed using reasonable skill and care, and be of a quality conforming to generally accepted industry standards and practices.

Except as expressly stated, all warranties whether express or implied, by operation of law or otherwise, are hereby excluded in relation to the goods and services to be provided by the Supplier.

All warranty services are provided on a return to base basis. Any transportation costs for the return of a warranty claim shall reside with the Customer.

## D.6 REACH Compliance

Regulation (EC) No. 1907/2006

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

Michell Instruments is a manufacturer of moisture measurement and gas analysis instrumentation and is a 'downstream' user of chemicals, as described by the EU Council Directive 76/769/EEC. The products we supply are not raw chemical products (goods).

Under normal and reasonably foreseeable circumstances of application, the goods supplied to you shall not contain or release any prohibited chemicals. No listed SVHC (Substances of Very High Concern) appear within products manufactured by Michell Instruments. Therefore the 0.1% mass per product, or total usage of 1 tonne/year, will never be exceeded. For these reasons we are neither required by obligation for registration nor for the creation of material safety data sheets (MSDS) for our products.

Our continued review of the SVHC Candidate List and latest additions is to ensure we remain compliant.

Michell Instruments maintains a hazardous material register in which MSDS data sheets are collated, and we will check that our suppliers will comply to REACH requirements for all materials and substances we use in the processes of our manufacturing.

In the unlikely event that any chemicals of concern appear in our products in quantities greater than 0.1% of total mass per product we will immediately inform you by correspondence according to the REACH Article 33 requirements. Our current appraisal is, however, that we do not expect or foresee such an incidence.

January 2013

## D.7 Calibration Facilities

Michell Instruments' calibration facilities are among the most sophisticated in the world and have been recognized for their excellence.

Traceability to the National Physical Laboratory (NPL) UK is achieved through our UKAS Accreditation (Number 0179). This covers dew point over the range -90 to +90°C (-130 to +194°F) and also Relative Humidity.

Dew-point calibrations are also traceable to the National Institute for Standards & Technology (NIST) USA over the range -75 to +20°C (-103 to +68°F).

**NOTE: Standard traceable calibration certificates for instruments and sensors are not issued under our UKAS accreditation. UKAS certificates are usually to special order and are clearly identified.**

## D.8 Return Policy

If a Michell Instruments' product malfunctions within the warranty period, the following procedure must be completed:

1. Notify a Michell Instruments' distributor, giving full details of the problem, the model variant and the serial number of the product.
2. If the nature of the problem indicates the need for factory service then the instrument should be returned to Michell Instruments, carriage prepaid, preferably in the original packaging, with a full description of the fault and the customer contact information.
3. Upon receipt, Michell Instruments will evaluate the product to determine the cause of the malfunction. Then, one of the following courses of action will be taken:
  - If the fault is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.
  - If Michell Instruments determines that the fault is not covered under the terms of the warranty, or if the warranty has expired, an estimate for the cost of the repairs, at standard rates, will be provided. Upon receipt of the owner's approval to proceed, the product will be repaired and returned.

## D.9 Manufacturing Quality

Michell Instruments is registered with the British Standards Institute for Quality Assurance to:

BS EN ISO 9001: 2008

Rigorous procedures are performed at every stage of production to ensure that the materials of construction, manufacturing, calibration and final test procedures meet the requirements laid down by our BSI approved Quality System.

Please contact Michell Instruments ([www.michell.com](http://www.michell.com)) if the product does not arrive in perfect working order.

# Appendix E

## Analyzer Return Document & Decontamination Declaration

## Appendix E Analyzer Return Document &amp; Decontamination Declaration

## Decontamination Certificate

**IMPORTANT NOTE:** Please complete this form prior to this instrument, or any components, leaving your site and being returned to us, or, where applicable, prior to any work being carried out by a Michell engineer at your site.

Instrument			Serial Number	
Warranty Repair?	YES	NO	Original PO #	
Company Name			Contact Name	
Address				
Telephone #			E-mail address	
Reason for Return /Description of Fault:				
Has this equipment been exposed (internally or externally) to any of the following? Please circle (YES/NO) as applicable and provide details below				
Biohazards			YES	NO
Biological agents			YES	NO
Hazardous chemicals			YES	NO
Radioactive substances			YES	NO
Other hazards			YES	NO
Please provide details of any hazardous materials used with this equipment as indicated above (use continuation sheet if necessary)				
Your method of cleaning/decontamination				
Has the equipment been cleaned and decontaminated?			YES	NOT NECESSARY
Michell Instruments will not accept instruments that have been exposed to toxins, radio-activity or bio-hazardous materials. For most applications involving solvents, acidic, basic, flammable or toxic gases a simple purge with dry gas (dew point <-30°C) over 24 hours should be sufficient to decontaminate the unit prior to return. <b>Work will not be carried out on any unit that does not have a completed decontamination declaration.</b>				
<b>Decontamination Declaration</b>				
I declare that the information above is true and complete to the best of my knowledge, and it is safe for Michell personnel to service or repair the returned instrument.				
Name (Print)			Position	
Signature			Date	

**NOTES:**



<http://www.michell.com>