



**OPERATING INSTRUCTIONS  
FOR  
Model 300P  
Percent Oxygen Transmitter**



	<b>DANGER</b>	
<p>HIGHLY TOXIC AND/OR FLAMMABLE LIQUIDS OR GASES MAY BE PRESENT IN THIS MONITORING SYSTEM. PERSONAL PROTECTIVE EQUIPMENT MAY BE REQUIRED WHEN SERVICING THIS SYSTEM.</p> <p>HAZARDOUS VOLTAGES EXIST ON CERTAIN COMPONENTS INTERNALLY WHICH MAY PERSIST FOR A TIME EVEN AFTER THE POWER IS TURNED OFF AND DISCONNECTED.</p> <p>ONLY AUTHORIZED PERSONNEL SHOULD CONDUCT MAINTENANCE AND/OR SERVICING. BEFORE CONDUCTING ANY MAINTENANCE OR SERVICING CONSULT WITH AUTHORIZED SUPERVISOR/MANAGER.</p>		

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### Warranty

This equipment is sold subject to the mutual agreement that it is warranted by us free from defects of material and of construction, and that our liability shall be limited to replacing or repairing at our factory (without charge, except for transportation), or at customer plant at our option, any material or construction in which defects become apparent within one year from the date of shipment, except in cases where quotations or acknowledgements provide for a shorter period. Components manufactured by others bear the warranty of their manufacturer. This warranty does not cover defects caused by wear, accident, misuse, neglect or repairs other than those performed by Teledyne or an authorized service center. We assume no liability for direct or indirect damages of any kind and the purchaser by the acceptance of the equipment will assume all liability for any damage which may result from its use or misuse.

We reserve the right to employ any suitable material in the manufacture of our apparatus, and to make any alterations in the dimensions, shape or weight of any parts, in so far as such alterations do not adversely affect our warranty.

### Important Notice

This instrument provides measurement readings to its user, and serves as a tool by which valuable data can be gathered. The information provided by the instrument may assist the user in eliminating potential hazards caused by his process; however, it is essential that all personnel involved in the use of the instrument or its interface, with the process being measured, be properly trained in the process itself, as well as all instrumentation related to it.

The safety of personnel is ultimately the responsibility of those who control process conditions. While this instrument may be able to provide early warning of imminent danger, it has no control over process conditions, and it can be misused. In particular, any alarm or control systems installed must be tested and understood, both as to how they operate and as to how they can be defeated. Any safeguards required such as locks, labels, or redundancy, must be provided by the user or specifically requested of Teledyne at the time the order is placed.

Therefore, the purchaser must be aware of the hazardous process conditions. The purchaser is responsible for the training of personnel, for providing hazard warning methods and instrumentation per the appropriate standards, and for ensuring that hazard warning devices and instrumentation are maintained and operated properly.

Teledyne Analytical Instruments (TAI), the manufacturer of this instrument, cannot accept responsibility for conditions beyond its knowledge and control. No statement expressed or implied by this document or any information disseminated by the manufacturer or its agents, is to be construed as a warranty of adequate safety control under the user's process conditions.

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## Model 300P

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Model 300P complies with all of the requirements of the Commonwealth of Europe (CE) for Radio Frequency Interference, Electromagnetic Interference (RFI/EMI), and Low Voltage Directive (LVD).

The following International Symbols are used throughout the Instruction Manual for your visual and immediate warnings and when you have to attend CAUTION while operating the instrument:



**GROUND**  
**Protective Earth**



**CAUTION**, The operator needs to refer to the manual for further information. Failure to do so may compromise the safe operation of the equipment.

## **Introduction**

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### **1.1 General**

The Model 300P Percent Oxygen Transmitter is designed to accurately monitor the oxygen content on a percent basis in a wide variety of gases. The Percent Oxygen Transmitter is equipped with two oxygen analysis ranges, 0–25% and 0–20.9% (air calibration range). The Model 300P is approved by Factory Mutual (FM) as intrinsically safe for operation in Class 1, Division 1, Groups A, B, C, and D hazardous environments.

The heart of the transmitter is Teledyne Brown Engineering's Micro-Fuel Cell oxygen sensor. This cell is a sealed electrochemical device which translates the amount of oxygen present in a sample into an electrical current. Since it is sealed, there is no electrolyte to change or electrodes to clean and therefore, virtually maintenance free.

The transmitter operates from a 24 VDC (nominal) power source and produces a 4–20 mA dc current output that is directly and linearly proportional to the oxygen concentration. The output current is used to interface with devices such as recorders, alarms, computers or other current driven devices.

### **1.2 Features**

The following features describe the basic model. The exact configuration depends on the options selected at the time of purchase.

- Two analysis ranges: 0–25% and 0–20.9%
- High sensitivity (0.5%)
- Accurate ( $\pm 2\%$  of full scale at constant temperature and pressure of calibration) or  $\pm 5\%$  of full scale over the operating temperature range.

- Insensitive to flow variations
- Fast response and recovery
- Long life, maintenance-free Micro-Fuel Cell oxygen sensor
- Unaffected by reducing agents (HC's, CO, SO<sub>2</sub>, etc.)
- Easy to calibrate, no zero gas required
- RFI Protection
- 2-wire (loop-powered) with 4–20 mA dc output
- Rugged bulkhead mounted metal enclosure
- FM approved as intrinsically safe (when used with approved safety barriers)
- Compact size, easy to install

### 1.3 Typical Applications

The Model 300P Percent Oxygen Transmitter is capable of monitoring oxygen at the % level in a variety of gases. It is widely used in industry. A few typical applications are:

- Monitoring inert gas blanketing
- Air separation and liquefaction
- Chemical feedstock analysis
- Semiconductor manufacturing
- Petrochemical process control
- Heat treating and bright annealing processes
- Quality assurance
- Gas certification
- Welding applications
- Flue gas analysis.

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## Operational Theory

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### 2.1 Transmitter Description

The transmitter consists of an RFI proof enclosure which contains the O<sub>2</sub> Sensor Assembly, 2-Wire Transmitter Circuitry and RFI Filters. Mounted on the left side is a junction box which contains a three conductor terminal strip for all external electrical connections. The bottom of the box contains two bulkhead fittings for the 1/8" tubing used for bringing the sample into and out of the sensor assembly. The transmitter assembly contains four holes in the mounting flange for vertical surface mounting. Access to the junction box is obtained by the removal of two screws followed by the removal of the cover. Access to the O<sub>2</sub> sensor and PC board is through an RFI gasketed door held shut by 4 screw clamps.

### 2.2 Sensor Description

The Micro-Fuel Cell is a sealed plastic disposable oxygen transducer that measures 1¼ inches in diameter and is ¾ inch thick (see Figure 2-1). Inside of the cell are a cathode and anode immersed in 15% aqueous KOH electrolyte. At one end of the sensor is a Teflon diffusion membrane; the other end is sealed with a polyethylene membrane. At the rear of the cell is a contact plate consisting of two concentric foils. The foils mate with spring-loaded contacts in the sensor block assembly and provide the electrical connection to the rest of the analyzer.

The sensing cathode, located beneath the diffu-

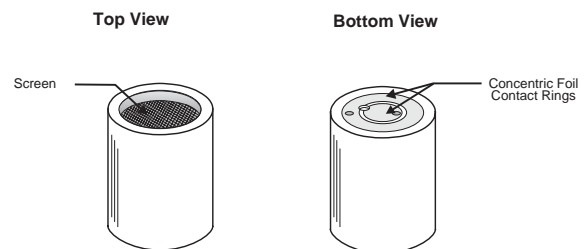


Figure 2-1: Micro-Fuel Cell

sion membrane, has a surface area of 2.48 cm<sup>2</sup>. The sample gas enters the sensor block through an inlet tube between the cathode and the sensor block cap, diffuses through the Teflon membrane, and any oxygen in the sample gas is reduced on the surface of the cathode by the following mechanism:

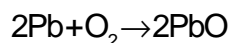


When the oxygen is reduced at the cathode, lead is simultaneously oxidized at the anode by the following mechanism.



The electrons released at the surface of the anode flow to the cathode surface via an external circuit. This current is proportional to the amount of oxygen. It is measured and used to determine the oxygen concentration in the gas mixture.

The overall reaction for the fuel cell is:



The output of the fuel cell is limited by the amount of oxygen in the cell at any one time, and the amount of stored anode material. In the absence of oxygen, there is no current generated.

**Warning:** The sensor used in the Model 300P uses electrolytes which contain substances that are extremely harmful if touched, swallowed, or inhaled. Avoid contact with ANY fluid or powder in or around the unit. What may appear to be plain water could contain one of these toxic substances. In case of eye contact, immediately flush eyes with water for at least 15 minutes. Call physician. (See Appendix - Material Safety Data Sheet (MSDS)).

### 2.3 Circuit Description

The 300P circuitry consists of four stages: an input stage, a temperature compensation/ gain stage, a low-pass filter and an output voltage-to-current stage. The output of the O<sub>2</sub> cell is a current directly proportional to the amount of oxygen present. The input stage converts this current to a voltage signal.

The temperature compensation stage consists of circuitry that amplifies the signal by a factor which is dependent upon the O<sub>2</sub> cell temperature. This temperature dependent gain is used to compensate for the rise in output current of the O<sub>2</sub> cell with temperature. A thermistor mounted in the sensor assembly monitors this temperature and changes resistance (up

with lower temperature, down with higher temperature) so that the output of this stage is constant over the temperature range at any given O<sub>2</sub> concentration.

The output voltage-to-current stage (E to I) draws 4 mA from the power supply loop when there is no oxygen present in the sample gas, and 20 mA when there is full scale oxygen present in the sample gas. It also supplies the +5V and -5V required by the circuitry.

A 24V power supply is recommended to power the transmitter for most applications. The actual minimum and maximum values of this supply depend upon the total loop resistance, which consists of the input resistance of the receiver and the resistance of the wires between the transmitter and the power supply. Power applied across the terminals of the transmitter must be between 14V and 30V. Using this criteria, the maximum line resistance can be determined. For example, with a 24V power supply, a maximum of 10V is available (24V-14V) for drop across the input resistance of the receiver and the line resistance. This amounts to a maximum loop resistance of approximately 500 ohms (10V divided by 0.02A).

The B-2 or B-2C cell used in this instrument normally generates about 500  $\mu$ A output current in air (20.9% O<sub>2</sub>). This is about 2 nA per ppm.

## 2.4 RFI Protection

The Model 300P is designed to be RFI protected by virtue of the electronics being mounted inside a grounded metallic enclosure. The RFI protection, therefore, is maximized when the enclosure door is closed.



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## Operation

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Operation of the Model 300P Percent Oxygen Transmitter involves installing the unit, making appropriate sample gas connections, and calibration.

### 3.1 Installation

**WARNING:** For FM approved intrinsically safe operation, an approved safety barrier must be used to limit the line power to 26 VDC and 125 mA.

#### 3.1.1 System Power Requirements

The Model 300P Percent Oxygen Transmitter requires a 24 VDC (nominal), reverse polarity protected power source. The maximum and minimum voltage is dependent on the safety barrier used.

#### 3.1.2 Transmitter

The transmitter enclosure is a weather resistant bulkhead mounted enclosure. Mount the enclosure to a vertical surface using the four mounting holes in the flange. Mount the enclosure with the sensor pointing down in a location where service personnel can reach it.

**WARNING:** If the enclosure is to be installed in a hazardous area, it must be interconnected with approved intrinsic safety barriers.

Make gas line connections to the sample in and sample out  $\frac{1}{8}$  " tube fittings at the bottom of the enclosure.

#### 3.1.3 Junction Box

Power connections are made at the junction box located on the side of the transmitter housing.

1. Remove the two screws securing the junction box cover and remove the cover.

2. Connect the 2-wire shielded cable to the three terminal barrier strip.
3. Replace the cover and screws.

### 3.2 Calibration

The calibration process consists of:

- Installing a milliammeter in series with the output signal as described below
- Setting the electronic zero level
- Setting the span

Setting the zero and span of the transmitter requires adjustment of two potentiometers (P1 and P2) located on the PC board inside the transmitter box.

**NOTE: If the analyzer has more than one range, the selector switch should be set to "B" (0-21%) during calibration and "A" during measurement operations.**

The Transmitter can be calibrated using either AIR or SPAN GAS. Both methods are accomplished by adjusting two potentiometers (ZERO and SPAN) located on the PC board inside the transmitter box.

Procedure:

1. Remove the junction box cover and remove the incoming wire from terminal 2 of the barrier strip.
2. Connect a milliammeter in series between this wire and terminal 2.

#### 3.2.1 Installing the Milliammeter

3. Remove the junction box cover and remove the incoming wire from terminal 2 of the barrier strip.
4. Connect a milliammeter in series between this wire and terminal 2.

**3.2.2 Setting the Electronic Zero Potentiometer (P2)** 5. Open the transmitter box door and remove the Micro-Fuel Cell. Adjust P2 for a meter reading of 4.00 +/- 0.01 mA.

6. Replace the Micro-Fuel Cell. Allow the reading to drop to a stable low level (dependent upon the length of time that the Micro-Fuel Cell was unshorted).

### 3.2.2 Setting the Span Potentiometer (P1) using AIR

7. Set switch SW-1 to position "B" (AIR CAL) and flow air through the system. This can be done by either disconnecting the sample line and allowing air to flow or inserting a tee with appropriate valves to allow switching between sample and air without having to disconnect the sample in line.
8. After the reading was stabilized, set P1 to read a stable 20.00 +/- 0.01 mA output.
9. Return switch SW-1 to the operating position "A".

### 3.2.3 Setting the Span Potentiometer (P1) using SPAN GAS

8. Set switch SW-1 to the normal operating position "A". Flow a span gas through the system and allow time for stabilization.  
NOTE: The span gas should have an O<sub>2</sub> concentration of 80% - 100% of full scale. For example, if you have a 0-10% transmitter, the span gas should be a certified grade gas of about 9% O<sub>2</sub> in N<sub>2</sub> or Argon.
9. Adjust span potentiometer P1 to read an output current determined by the following equation:

$$\frac{\text{Span Gas Concentration in \%}}{\text{Full Scale Concentration in \%}} + 4 \text{ mA} = \text{Output in mA}$$

10. Remove meter and reconnect incoming wire to Terminal 2. Replace junction box cover and close transmitter box door.

## 3.3 Operating the Oxygen Transmitter

1. After calibrating the instrument, reconnect the sample in line if it was disconnected.
2. Open the transmitter door and set switch SW-1 back to position "A" if this has not already been done.

**CAUTION:** The 0–25% oxygen analysis range can be used to accurately measure the oxygen concentration in a gas mixture containing up to 24% Oxygen. Oxygen concentrations above 24% under extreme conditions can cause the instrument to produce unreliable readings on the 0–25% oxygen scale. Use this range for gas mixtures containing 0–24% oxygen only.



## Maintenance

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### 4.1 Routine Maintenance

Aside from normal cleaning and checking for leaks at the gas connections, routine maintenance is limited to installing replacement Micro-Fuel cells and recalibration. For recalibration, see section 3.2 *Calibration*.

### 4.2 Cell Replacement

The Micro-Fuel Cell is a sealed electrochemical transducer with no electrolyte to change or electrodes to clean. When the cell reaches the end of its useful life, it is replaced. The spent fuel cell should be discarded according to local regulations.

The characteristics of the Micro-Fuel Cell are similar to those of a mercury battery in that both provide an almost constant output throughout their useful life, and then fall off sharply towards zero at the end. If the process being analyzed has a low oxygen concentration, cell failure will probably be indicated by the inability to properly span calibrate the transmitter, or excessively long response time to changes in oxygen concentration.

To avoid downtime, TBE/AI recommends that a spare cell be purchased shortly after the instrument is placed in service, and each time the cell is replaced.

The spare cell should be carefully stored in an area that is not subject to large variations in ambient temperature (75°F nominal), and in such a way as to eliminate the possibility of incurring damage.

**NOTE: Do not disturb the integrity of the cell package until the cell is to actually be used. If the cell package is punctured and air is permitted to enter, the useful life of the cell will be adversely affected.**

To replace the cell:

1. Open the enclosure door.
2. The cell block is located in the center of the unit. Unscrew the cap on the bottom of the cell block. The micro-fuel cell should drop down once the cap is removed.

**NOTE:** Minimize the amount of time the cell is exposed to air. This will lessen the time it will take the newly installed cell to drop to a zero reading.

3. Remove the new cell from its package, and carefully remove the shorting clip.

**NOTE:** Do not touch the silver colored sensing surface of the cell, as it is covered with a delicate Teflon membrane that can be ruptured in handling. Puncturing or other damage will require replacement of the sensor

**WARNING:** *The sensor used in the Model 300P uses electrolytes which contain substances that are extremely harmful if touched, swallowed, or inhaled. Avoid contact with ANY fluid or powder in or around the unit. What may appear to be plain water could contain one of these toxic substances. In case of eye contact, immediately flush eyes with water for at least 15 minutes. Call physician. (See Appendix - Material Safety Data Sheet (MSDS)).*

4. Place the new cell on the cap with the sensing surface face down and the gold contact rings up.
5. Position the cell and cap so that the cell is inside the cell block. Press up on the cap and rotate until it threads. Tighten the cap.

### 4.3 Cell Warranty

The Class B-1 cell employed in the Model 300P is warranted for six months of service. Other special cells may be used on occasion, depending upon the application. Note any Addenda attached to the front of this manual for special information applying to your instrument.

With regard to spare cells, warranty period begins on the date of shipment. The customer should stock only one spare cell per instrument at a time. Do not attempt to stockpile spare cells.

The B-1 cell should not be used in applications where CO<sub>2</sub> is a major component in the sample, however concentrations of 1,000 ppm or less will not adversely effect the cell performance. Consult TBE/AI for optional

cells which are available for either intermittent or continuous CO<sub>2</sub> exposure.

If a cell was working satisfactorily, but ceases to function before the warranty period expires, the customer will receive credit toward the purchase of a new cell.

If you have a warranty claim, you must return the cell in question to the factory for evaluation. If it is determined that failure is due to faulty workmanship or material, the cell will be replaced at no cost to the customer.

**NOTE: Evidence of damage due to tampering or mishandling will render the cell warranty null and void.**



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## Appendix

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**System Enclosure:** Weather resistant, bulkhead mounted

**Power Requirements:** 24V nominal, reverse polarity protected.  
 $V_{\max}$  and  $V_{\min}$  dependent upon safety barrier used. For Factory Mutual Approved Intrinsically Safe Operation, an approved safety barrier must be used to limit line power to  $V_{\max} = 26$  VDC and  $I_{\max} = 125$  mA.

**Ranges:** 0–25% Oxygen

**Accuracy:**  $\pm 2\%$  of full scale at constant temperature and pressure (temperature and pressure of calibration), except  $\pm 1$  ppm on 0–10 ppm range.  
 $\pm 5\%$  of full scale over operating temperature range (once thermal equilibrium has been reached), except  $\pm 1$  ppm on 0–10 ppm range.

**Response Time (90%):** Sensor Response Time + Electronic Response Time = 61 seconds @ 77°F (25°C).

**Operating Temperature:** 32–122°F (0–50°C)

**Stability:**  $\pm 1\%$  in 24 hours (at constant temperature)

**Reproducibility:**  $\pm 1\%$  of full scale at constant temperature

**Sensor Type:** Micro-Fuel Cell class B-3

**Signal Output:** 4–20 mA DC

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### Recommended Spare Parts List

QTY.	PART NUMBER	DESCRIPTION
1	C48672	PC Board — 2 Wire Transmitter
1	I109	IC — XTR101AG
1	C6689-B3	Micro-Fuel Cell

A minimum charge is applicable to spare parts orders.

**NOTE: Orders for replacement parts should include the part number (if available ) and the model and serial number of the instrument for which the parts are intended.**

Orders should be sent to:

#### Teledyne Analytical Instruments

16830 Chestnut Street  
City of Industry, CA 91749-1580  
Phone (626) 934-1500, Fax (626) 961-2538  
TWX (910) 584-1887 TDYANLY COID

Web: [www.teledyne-ai.com](http://www.teledyne-ai.com)

or your local representative

#### Drawing List

B-50966 Outline Diagram  
B-49326 Wiring Diagram  
A-41453 Interconnection Diagram  
B-48671 Schematic — 2 Wire Transmitter

**NOTE: The MSDS on this material is available upon request through the Teledyne Environmental, Health and Safety Coordinator. Contact at (626) 934-1592**

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**Material Safety Data Sheet**
**Section I – Product Identification**

**Product Name:** Micro-Fuel Cells  
 Mini-Micro-Fuel Cells, all classes  
 Super Cells, all classes except T-5F  
 Electrochemical Oxygen Sensors, all classes.

**Manufacturer:** Teledyne Analytical Instruments

**Address:** 16830 Chestnut Street, City of Industry, CA 91749

**Phone:** (818) 961-9221

Date Prepared or Last Revised: 08/08/91

Emergency Phone Number: (818) 961-9221

**Section II – Physical and Chemical Data**

Chemical and Common Names: Potassium Hydroxide (KOH), 15% (w/v)  
 Lead (Pb), pure

CAS Number: KOH 1310-58-3  
 Pb 7439-92-1

	<b>KOH (15%)</b>	<b>Pb (pure)</b>
Melting Point/Range:	-10 to 0 °C	328 °C
Boiling Point/Range:	100 to 115 °C	1744 °C
Specific Gravity:	1.09 @ 20 °C	11.34
pH:	>14	N/A
Solubility in Water:	Completely soluble	Insoluble
Percent Volatiles by Volume:	None	N/A
Appearance and Odor:	Colorless, odorless solution	Grey metal, odorless

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### Section III – Physical Hazards

**Potential for fire and explosion:** The electrolyte in the Micro-Fuel Cells is not flammable. There are no fire or explosion hazards associated with Micro-Fuel Cells.

**Potential for reactivity:** The sensors are stable under normal conditions of use. Avoid contact between the sensor electrolyte and strong acids.

### Section IV – Health Hazard Data

<b>Primary route of entry:</b>	Ingestion, eye/skin contact
<b>Exposure limits:</b> OSHA PEL:	.05 mg/cu.m. (Pb)
ACGIH TLV:	2 mg/cu.m. (KOH)
<b>Effects of overexposure</b>	
<b>Ingestion:</b>	The electrolyte could be harmful or fatal if swallowed. Oral LD50 (RAT) = 3650 mg/kg
<b>Eye:</b>	The electrolyte is corrosive; eye contact could result in permanent loss of vision.
<b>Dermal:</b>	The electrolyte is corrosive; skin contact could result in a chemical burn.
<b>Inhalation:</b>	Liquid inhalation is unlikely.
<b>Signs/symptoms of exposure:</b>	Contact with skin or eyes will cause a burning sensation and/or feel soapy or slippery to touch.
<b>Medical conditions</b>	
<b>aggravated by exposure:</b>	None
<b>Carcinogenicity:</b>	NTP Annual Report on Carcinogens: Not listed LARC Monographs: Not listed OSHA: Not listed
<b>Other health hazards:</b>	Lead is listed as a chemical known to the State of California to cause birth defects or other reproductive harm.

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**Section V – Emergency and First Aid Procedures**

- Eye Contact:** Flush eyes with water for at least 15 minutes and get immediate medical attention.
- Skin Contact:** Wash affected area with plenty of water and remove contaminated clothing. If burning persists, seek medical attention.
- Ingestion:** Give plenty of cold water. Do not induce vomiting. Seek medical attention. Do not administer liquids to an unconscious person.
- Inhalation:** Liquid inhalation is unlikely.

**Section VI – Handling Information**

**NOTE:** The oxygen sensors are sealed, and under normal circumstances, the contents of the sensors do not present a health hazard. The following information is given as a guide in the event that a cell leaks.

**Protective clothing:** Rubber gloves, chemical splash goggles.

**Cleanup procedures:** Wipe down the area several times with a wet paper towel. Use a fresh towel each time.

**Protective measures**

**during cell replacement:** Before opening the bag containing the sensor cell, check the sensor cell for leakage. If the sensor cell leaks, do not open the bag. If there is liquid around the cell while in the instrument, put on gloves and eye protection before removing the cell.

**Disposal:** Should be in accordance with all applicable state, local and federal regulations.

**NOTE:** The above information is derived from the MSDS provided by the manufacturer. The information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. Teledyne Analytical Instruments shall not be held liable for any damage resulting from handling or from contact with the above product.

