INSTRUCTION MANUAL

FOR

Model 335 Series

Oxygen Alarm Monitor

DANGER

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.

HAZARDOUS VOLTAGES EXIST ON CERTAIN COMPONENTS INTERNALLY WHICH MAY PERSIST FOR A TIME EVEN AFTER THE POWER IS TURNED OFF AND DISCONNECTED.

ONLY AUTHORIZED PERSONNEL SHOULD CONDUCT MAINTENANCE AND/OR SERVICING. BEFORE CONDUCTING ANY MAINTENANCE OR SERVICING CONSULT WITH AUTHORIZED SUPERVISOR/MANAGER.

M24692
ECO# 99-0011
10/08/99

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 TAI 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 TAI 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.

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.

DANGER: **ELECTRICAL SHOCK HAZARD**

Disconnect all power to this instrument before performing any maintenance. The PCBs within the enclosure contain dangerously high voltages sufficient to cause death or serious injury. Do not rely on the power switch alone to disconnect the AC power from the unit...DISCONNECT THE AC POWER CORD FROM THE AC POWER SOURCE before performing maintenance or placing your hands inside the enclosure.

WARNING: **This instrument is designed to be operated in a nonhazardous area. It is the customer's responsibility to ensure that proper training and understanding of the principles of operation of this equipment is understood by the user. Since the use of this instrument is beyond the control of Teledyne, no responsibility by Teledyne, its affiliates and agents for damage or injury resulting from misuse or neglect of this instrument is implied or assumed.**

Misuse of this product in any manner, tampering with its components or unauthorized substitution of any component may adversely affect the safety of this instrument.

CAUTION: **When operating this instrument, the doors must be closed and all covers securely fastened. The gauges must be in proper working order. Do not over-pressurize the system.**

Read this manual before operating the instrument and adhere to all warnings included in this manual.

Table of Contents

Introduction

The Teledyne Analytical Instruments (TAI) Model 335 Oxygen Alarm accurately measures the oxygen content of the atmosphere surrounding its sensor. The standard measurement range is 0-25% oxygen. The alarm feature of the instrument incorporates two adjustable setpoints to allow alarm warning under either of two independent oxygen level conditions. The standard alarm indication is produced by both an audible annunciator and a visual light, and when an alarm condition exists, a relay is energized to switch a set of relay contacts. Both normally open and normally closed circuits are provided by the Form “C” relay contacts; consult the Interconnection Diagram at the rear of the manual to find the interconnection terminals where the circuits can be accessed.

The instrument is designed as a safety monitor. However, it is the responsibility of the user to establish whether or not the total system or instrument, environment, alarm components and any other relevant devices will actually assure safety in his/her particular circumstances.

The “Safety Checklist” outlined in the “Pre-Operation” section of this manual should be treated as a guide only; it is up to the user to establish practical safety precautions. Also, it is vital that operator’s understand and test the operation of the complete system.

Consult the circuit-related drawings at the rear of the manual to find information about circuit paths (schematic) and connecting points (wiring and interconnection diagrams), as well as physical characteristics and dimensions (outline diagram). These drawings reflect the exact design and construction of your instrument.

DANGER: **Remove power from the system before opening the instrument or attempting to perform any maintenance.**

Operational Theory

2.1 Method of Analysis

The analysis is specific for oxygen, i.e., the measuring cell will not generate an output current unless oxygen is present in the sample gas. Thus, the instrument has an absolute zero and no zero gas is required to operate the analyzer.

The measuring cell has the ability to respond accurately to the presence of oxygen irrespective of flowrate. TAI recommends using ambient air as a span gas or, if that is not possible, using a known calibration gas of about 80% of the range of interest value.

The measuring cell (U.S. Patent #3,429,796) is a solid-state maintenance-free structure that carries a TAI guarantee for performance and usable life. The cell consumes oxygen from the gas surrounding it and generates a proportional microampere current. The low level signal is then amplified by a solid-state operational amplifier. The resulting DC signal is suitable for driving a high impedance recording device, a temperature compensation circuit for the cell and an integral 0-100µA meter. The output signal is linear over the specified ranges of analysis.

2.2 Micro-Fuel Cell Sensor

2.2.1 Principles of Operation

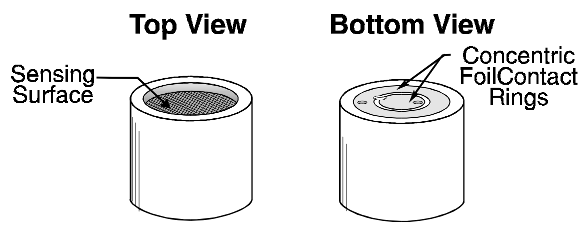
The oxygen sensor used in the Model 335 is a Micro-Fuel Cell (MFC) designed and manufactured by TAI. It is a sealed plastic disposable electrochemical transducer.

The active components of the MFC are a cathode, an anode and the 15% aqueous Potassium Hydroxide (KOH) electrolyte in which they are immersed. The cell converts the energy from a chemical reaction into an electrical potential that can produce a current in an external electrical circuit. Its action is similar to that of a battery.

There is, however, an important difference in the operation of a battery as compared to the MFC: in the battery, all reactants are stored within the cell, whereas in the MFC, one of the reactants (oxygen) comes from outside the device as a constituent of the sample gas being analyzed. The MFC is therefore a hybrid between a battery and a true fuel cell. (All of the reactants are stored externally in a true fuel cell.)

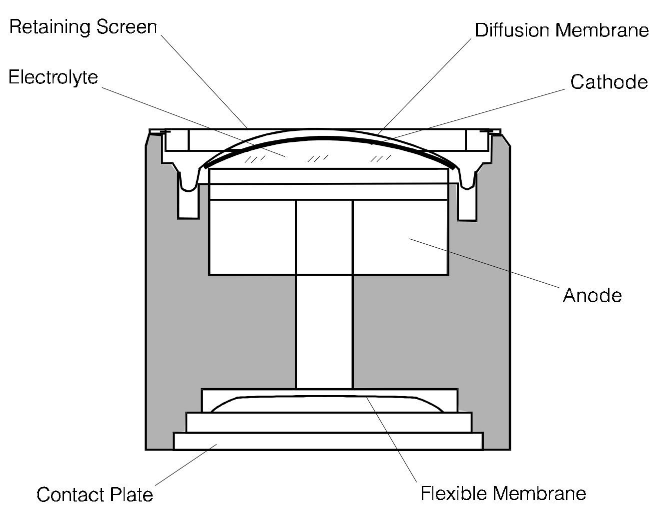
2.2.2 Anatomy of a Micro-Fuel Cell

The MFC is a cylinder only 1¼" in diameter and 1¼" thick. It is made of extremely inert plastic (which can be placed confidently in practically any environment or sample stream) and is effectively sealed, though one end is permeable to oxygen in the sample gas. At the permeable end a screen retains a diffusion membrane through which the oxygen passes into the cell. At the other end of the cell is a contact plate consisting of two concentric foil rings. The rings mate with spring-loaded contacts in the sensor block assembly and provide the electrical connection to the rest of the analyzer. Figure 2-1 illustrates the external features.



mfcouts.wmf

Figure 2-1: Micro-Fuel Cell



mfc-xsec.wmf

Figure 2-2. Cross Section of a Micro-Fuel Cell

At the top end of the cell, under the retaining screen, is a diffusion membrane of Teflon whose thickness is very accurately controlled. (See Figure 2-2.) Beneath the diffusion membrane lies the oxygen sensing element (cathode) with a surface area almost $2.5cm^2$. The cathode has many perforations to ensure sufficient wetting of the upper surface with electrolyte, and it is plated with an inert metal.

The anode structure is below the cathode. It is made of lead and has a proprietary design used to maximize the amount of metal available for chemical reaction.

At the rear of the cell, just below the anode structure, is a flexible membrane designed to accommodate the internal volume changes that occur throughout the life of the cell. This flexibility preserves the integrity of the structural elements surrounding the cathode and prevents the associated changes in electrical activity that would result.

The entire space between the diffusion membrane, above the cathode, and the flexible rear membrane, beneath the anode, is filled with electrolyte. Cathode and anode are submerged in this common pool. They each have a conductor connecting them to one of the external contact rings on the contact plate on the bottom of the cell.

2.2.3 Electrochemical Reactions

The sample gas diffuses through the Teflon membrane. Any oxygen in the sample gas is reduced on the surface of the cathode by the following HALF REACTION:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^- \qquad \text{(cathode)}$$

(Four electrons combine with one oxygen molecule in the presence of water from the electrolyte to produce four hydroxyl ions.)

When the oxygen is reduced at the cathode, lead is simultaneously oxidized at the anode by the following HALF REACTION:

$$2(Pb + 2OH^-) \rightarrow 2(Pb^{+2} + H_2O) + 4e^- \qquad \text{(anode)}$$

(Two electrons are transferred for each atom of lead that is oxidized. TWO ANODE REACTIONS balance one cathode reaction to transfer four electrons.)

The electrons released at the surface of the anode flow to the cathode surface when an external electrical path is provided. The current is proportional to the amount of oxygen reaching the cathode. It is measured and used to determine the oxygen concentration in the gas mixture.

The overall reaction for the fuel cell is the SUM of the half reactions above, or:

$$2Pb + O_2 \rightarrow 2PbO$$

(These reactions will hold as long as no gaseous components capable of oxidizing lead are present in the sample. The only likely components are the halogens: iodine, bromine, chlorine and fluorine.)

The output of the fuel cell is limited by (1) the amount of oxygen in the cell at the time and (2) the amount of stored anode material.

In the absence of oxygen, no current is generated.

2.2.4 The Effect of Pressure

In order to state the amount of oxygen present in the sample as a portion (parts-per-million {ppm} or percent {%}) of the gas mixture, it is necessary that the sample diffuse into the cell under constant pressure.

If the pressure changes, the rate that oxygen reaches the cathode through the diffusing membrane will also increase. The electron transfer, and therefore the external current, will increase, even though the proportion of oxygen has not changed.

From Dalton's Law, the partial pressure of each gas in a mixture is the same pressure that it would exert if it were alone given the same amount and confined to the same volume. This means that as long as the total pressure of the sample remains constant, the mixture can change, but the diffusion of the oxygen will be affected only by the concentration of the oxygen.

For this reason, the sample system supplying sample gas to the cell is designed to keep the pressure on the diffusion membrane constant.

2.2.5 Calibration Characteristics

Given that the total pressure of the sample gas at the surface of the MFC input is constant, a convenient characteristic of the cell is that the current produced in an external circuit of constant impedance is directly proportional to the rate at which oxygen molecules reach the cathode, and this rate is directly proportional to the concentration of oxygen in the gaseous mixture. In other words it has a linear characteristic curve, as shown in Figure 2-3 (using arbitrary units). Measuring circuits do not have to compensate for nonlinearities.

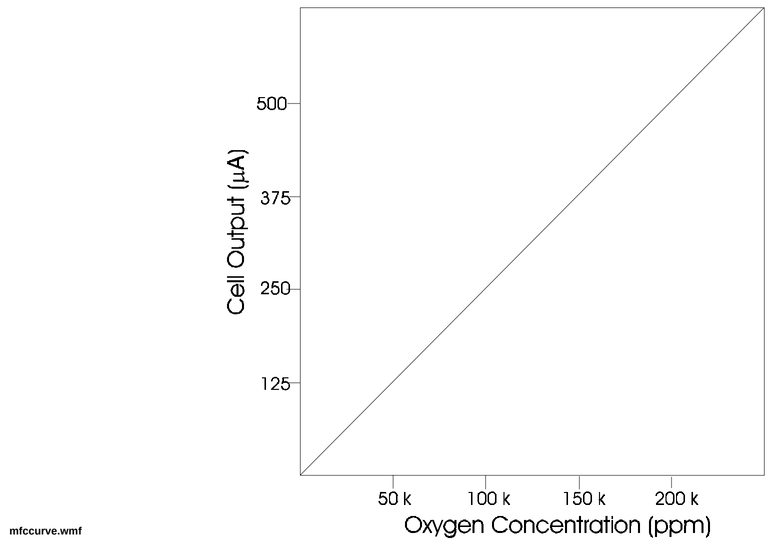


Figure 2-3. Characteristic Input/Output Curve for a Micro-Fuel Cell

In addition, since there is zero output in the absence oxygen, the characteristic curve has an absolute zero. The cell itself does not need to be zeroed. In practical application, however, zeroing is still used to compensate for a number of other variables in the instrument and in the environment of the instrument.

2.3 Circuit Description

Follow this description on the Circuit Schematic in the Drawings section at the rear of this document.

The measuring cell produces a current signal that is acted upon by the thermistor, resistor and span potentiometer network to produce a temperature compensated voltage signal. The voltage signal (about 100mV 20%) is applied to the CW terminal of the span pot (P1). A portion (about half) of the voltage, as determined by the position of the span pot slider, is applied to amplifier A1. Offset zero adjustment is provided at this point by zero potentiometer P2. Capacitors C1 (RFI filter) and C2 (noise filter) improve the signal quality to ensure clean amplification by A1. Adjustment of the span pot can now cause the signal voltage, amplified twenty-fold by A1, to equal 1V full scale at the amplifier's output.

The amplified 1V signal is fed to the meter, and a full scale meter response with 1V applied is accomplished by adjustment of potentiometer P6. Comparator sections A2a and A2b, biased by setpoint potentiometers P5 and P4, respectively, provide direct activation of the alarm relays and

LED's; they also enable the oscillator of the audible (beeper) alarm. The alarm relays themselves are ultra-sensitive and require only a few milliamps driving current. Jumpers A through H and J through R allow the alarms to be connected in either LOW or HIGH configuration. The reference voltage for the alarm comparators is taken from the reference comparator circuit (which also monitors the battery and AC line voltage levels.)

Comparator sections A2c and A2d compare the battery voltage and a voltage corresponding to the AC line voltage with a 1V reference level produced by A1b from D7 and P3. To represent the line voltage, the secondary of the power transformer and a voltage divider are used. If either the battery voltage or the AC line voltage drop below relative preset levels, the appropriate LED will light. Low voltage LED signals must be acknowledged and the problem corrected as soon as possible; eventually, the battery voltage will weaken to the point that the LED's cease to warn of the problem.

The 1V reference is also applied to the two alarm setpoint networks consisting of P4/P19 (CAUTION SET) and R20/P5/R21 (DANGER SET), which supply the reference voltages for the two alarm comparators. The positions of the sliders of setpoint potentiometers P4 and P5 determine the reference levels of the two comparators, and consequently provide the setpoints of the two alarms.

2.4 Alarms

When the alarm setpoints are properly adjusted, they provide an operational band that covers all acceptable oxygen concentrations. If the oxygen level at the sensor crosses the adjusted setpoint of one of the alarms, that alarm will cause the switching of relay contacts. Normally open (N.O.) and normally closed (N.C.) circuit connections at the interconnection terminal strip will be reversed. Thus, a circuit that is open (turned off) in a non-alarm condition will be closed (turned on) when its alarm is activated, and vice-versa.

As per OSHA specifications, the standard factory setting of the two alarms provides a "CAUTION" alarm at 20% oxygen (at the sensor) and a "DANGER" alarm at 19.5% oxygen. To cover special cases, a limited amount of adjustment is possible.

Installation and Operation

Installation consists of installing the Micro-Fuel Cell, installing the rechargeable batteries and connecting the instrument to the AC power.

3.1 Installing the Micro-Fuel Cell

The Micro-Fuel Cell is shipped separately from the instrument and must be installed before operating the instrument. Turn the instrument off and disconnect the AC power.

To install the cell in the probe assembly:

1. Remove the probe from its holder inside the instrument case and remove the cell from its sealed shipping package.
2. Unscrew the cap from the top of the probe assembly.
3. Remove the shorting clip from the cell. REMOVE THE MEMBRANE END OF THE SHORTING CLIP FIRST so that it does not puncture the soft membrane.
4. Place the cell in the probe with the terminal end facing down toward the probe contacts and the soft membrane surface facing the outside.
5. Replace the probe cap, making sure that it is all the way down and seated on the probe body, then replace the probe assembly into its holder.

3.2 Power and Signal Connections

NOTE: Batteries are shipped disconnected.

Refer to manual for connection before operation.

3.2.1 AC and Battery Backed Standby Power

This instrument is designed to operate from a 115VAC @ 50/60 Hz power. As an option, if specified at the time of purchase, this instrument can be powered from 100 or 220VAC @ 50/60 Hz. Connect the included power cord to the AC power.

The Model 335 uses battery backed standby power during periods of power failure or "brown out" conditions. Power outages will not interfere with a properly-working Model 335 oxygen alarm if it is installed and used correctly. The standby power source uses rechargeable NiCad (Nickel Cadmium) batteries. If the AC power is temporarily impaired (“brown-out”) or interrupted, the stand-by power supply takes over and keeps the analyzer in operation.

Periodically test the condition of the battery pack by pressing the “BATTERY TEST” pushbutton on the instrument’s control panel and note the battery condition in the area so designated on the meter scale. Release the pushbutton to return to the normal sampling mode. The battery test provides only an indication of the battery state under the test conditions; it is possible that a battery might test well but perform for only a short time under actual operational conditions (a characteristic of the battery, not the analyzer), so it is very important that power outages be corrected without delay. Furthermore, TAI recommends that the instrument be tested periodically by operating it for several hours without AC power (that is, under battery power).

The standard Model 335 is designed to operate on standby battery power for at least six hours if conditions are favorable, i.e., conditions are not extreme and the batteries are well charged and in good condition). Under actual conditions, however, these factors will always tend to evolve toward the worst case if left unattended. Therefore, the user must always ensure that battery condition, charge and other related factors are monitored with sufficient frequency to prevent problems. Most importantly, DO NOT DEPEND UPON THE LONGEVITY OF BATTERY BACKUP, but correct problems as soon as possible.

3.2.2 Installing the Rechargeable NiCad Batteries

Connect the batteries as follows:

1. Remove the tape from the red wire and the white green wire.
2. Connect the red wire to TS2-5; connect the white green wire to TS2-6.

3.2.3 Signal Connections

Alarm relay and optional output signals are available to the user from a terminal block inside the enclosure. See the Interconnection Diagram included with the drawings at the back of this manual.

The CAUTION and DANGER alarms are equipped with separate relays. Each of these relays provides a single set of contacts rated for 2A resistive load @ 28VDC or 2A @ 120VAC.

A 0-1VDC signal output is available as an option that must be specified at the time of purchase. If you have chosen this option, the Oxygen Monitor will generate a 0-1VDC signal as output to represent the 0-25% oxygen range. This output signal is linear and proportional to the oxygen concentration within the 0-25% range. The output signal is available to the user from a terminal block inside the enclosure. (See the Interconnection Diagram included with the drawings at the rear of this document.)

3.3 Calibration

Prior to operating this instrument for the first time, the Oxygen Monitor must be calibrated. If this instrument is to be used as a safety monitor, routine calibration should be carried out on a weekly basis.

Calibration of a standard instrument is performed by exposing the sensor to ordinary ambient air (not the monitored atmosphere) and adjusting the “CALIBRATE” control until the meter pointer rests at the CAL mark on its scale. This mark represents the normal oxygen concentration of air (20.9%) under standard conditions, so be sure that the sensor is exposed to fresh air when using the calibration mark.

If it is not feasible to use ordinary air as the calibration gas, then clean, compressed instrument air can be used. It will probably be necessary to seal the sensor in the piped-in calibration gas to isolate it from the surrounding atmosphere. A flow-through adaptor can be purchased from TAI as an accessory for those applications. Although a special calibration gas can be used, the calibration results will be meaningless unless the oxygen concentration of the calibration gas is known, and the analyzer is adjusted to indicate that concentration. To eliminate any error caused by the calibration gas, always use a certified composition with an oxygen concentration between 80% and 90% of the full scale meter reading of the analyzer.

NOTE: ***Calibration in the same atmosphere that is being monitored can result in serious error. The analysis performed and the alarms, if any, generated by this instrument when calibrated using the monitored atmosphere or a span gas of unknown composition, will be meaningless.***

3.4 Operation

Once the instrument has been installed, calibrated, and the power turned on, it will continuously monitor the oxygen level within the environment it is placed. The oxygen level is displayed on the analog meter. The response time of the instrument will depend on the actual Micro-Fuel Cell (MFC) installed. With the class B-3 MFC installed, the response time is less than 15 seconds at 25°C. The table below indicates the response time for some MFCs typically used in the Model 335.

Class	Response Time (Sec)	Warranty (Months)	Application
B-3	13	12	Intermediate response/long life
B-5	13	18	Long life/general O_2 monitoring
C-3	30	12	General purpose/long life

3.5 Cell Warranty

The Class B-3 cell used in the Model 335 is warranted for 12 months of service. Under normal operating conditions the Class B-3 cell should last 12 months in air. For special applications, optional cells are available.

Customers having warranty claims must return the cell in question to the factory evaluation after obtaining an RMA number. If it is determined that failure is due to faulty workmanship or materials, the cell will be replaced free of charge. If a cell was working satisfactorily, but fails short of its warranty period, the customer will receive credit, on a prorated basis, toward the purchase of a new cell.

NOTE: ***Evidence of mishandling will render the cell warranty null and void.***

3.6 Safety Checklist

The following checklist is offered only as a guide to assist the user in verifying a number of important factors; it is by no means a complete list of safety-related items. The procedures and precautions relating to the use of the instrument in the user’s process must be developed by the user. It is vital that the operator understand and test the operation of the total system.

Verify that:

1. Instrument power is active and adequate.

2. Instrument functions are operational.
3. Alarm indicators are effective and produce intended results.
4. Unauthorized personnel are prevented from tampering with the instrument or auxiliary equipment.
5. Routine test and calibration procedures are instituted and followed.
6. Any and all sampling and/or location problems are identified and handled.
7. Any and all necessary warning labels, notices, and information are provided.
8. Operators understand the operations and functions of the analyzer and system.
9. Any environmental or other influences that could affect the operation or accuracy of the instrument are identified and handled.

3.7 Accessory Flow-Through Adapter

A flow-through adaptor is available for the Series 335 Oxygen Analyzer for those applications that require piped-in gases. The adaptor consists of a sealed chamber where the instrument's probe is inserted, with two radially-oriented hose connectors to which supply and vent lines for the calibration gas are connected. The design provides gas flow over the sensing surface of the cell without contamination by the surrounding monitored atmosphere.

Appendix

Specifications

Range:	0-25% Oxygen
Sensitivity:	0.5% of full scale
Accuracy:	±2% of full scale (at constant temperature) ±5% of full scale (over operating temperature range once the system has equilibrated)
Response Time:	90% in less than 15 seconds at 25°C (B-3 cell)
Operating Temperature:	15-45°C
Reproducibility:	± 1% of full scale
Sensor Type:	B-3, B-5, C-3
Readout:	High resolution $4\frac{1}{2}$" analog meter
Battery Life:	48 hours (non-alarm condition)
Power Requirements:	115VAC @ 50/60 Hz charges and maintains on trickle charge two NiCad battery packs.
Enclosure:	Dust-tight steel enclosure (wall mountable, two brackets top and bottom, each with two $\frac{5}{16}$" holes, 8" center-to-center). 11.5"(H) x 9"(W) x 4.125"(D) (22.9cm x 29.2cm x 10.4cm)
Weight:	11.7lbs (5.3Kg)
Alarms:	Factory Set: CAUTION = 20.0% DANGER = 19.5% Audible Horn Visual Red Indicator Lamps

Recommended Spare Parts List

Qty	P/N	Description
1	C-6689	Micro-Fuel Cell, Class B-3 (if non-standard, see "Specifications" Sheet)
4	B-76	Battery
1	M-69	Meter
1	F-8	Fuse, 1/2A Slo-Blo
1	L-52	Indicator Light (Red)
1	A-20	Alarm, Sonalert
1	P-102	Span Potentiometer
1	R-914	Relay
2	S-521	Spring, Relay Hold-Down

IMPORTANT: **Orders for replacement parts should include the part number, the model and serial numbers of the analyzer in which they are to be used.**

Orders should be sent to:

TELEDYNE ANALYTICAL INSTRUMENTS
16830 Chestnut Street
City of Industry, CA 91749-1580
Phone (626)961-1500,
Fax (626)961-2538
TWX (910)584-1887 TDYANLY COID or your local representative.

Web: www.teledyne-ai.com

Drawing List

C-24634	Outline Drawing
A-24690	Interconnection Diagram
B-24663	Schematic Diagram
C-24694	Wiring Diagram

Material Safety Data Sheet

Section I – Product Identification

Product Name: Micro-Fuel Cells and Super Cells, all classes except A-2C, A-3, and A-5.
Electrochemical Oxygen Sensors, all classes except R-19.
Mini-Micro-Fuel Cells, all classes.

Manufacturer: Teledyne Analytical Instruments
Address: 16830 Chestnut Street, City of Industry, CA 91749
Phone: (626) 934-1500
Technical Support: (626) 934-1673
Environment Health and Safety: (626) 934-1592

Section II – Hazardous Ingredients/Composition

Material or Component TLV	C.A.S. #	Quantity	OSHA PEL	ACGIH
Lead (Pb)	7439-92-1	3–20 gms	0.05 mg/m^3	0.15 mg/m^3
Potassium Hydroxide Solution 15% (KOH)	1310-58-3	1–5 ml	None	2 mg/m^3

Section III – Physical/Chemical Characteristics

Material Appearance or Component	Boiling Point (°C)	Specific Gravity	Vapor Pressure	Melting Point (°C)	Density	Evap. Rate	Solubility in Water	Odor
Lead	1744	11.34	na	328	na	na	Insoluble	Solid, silver gray, odorless
Potassium Hydroxide	1320	2.04	na	360	na	na	Complete	White or slightly yellow, no odor

Section IV – Fire and Explosion Hazard Data

Flash Point: na **Flammable Limits:** na **LEL:** na **UEL:** na

Extinguishing Media:	Use extinguishing media appropriate to surrounding fire conditions. No specific agents recommended.
Special Fire Fighting Equipment:	Wear NIOSH/OSHA approved self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.
Unusual Fire and Explosion Hazards:	Emits toxic fumes under fire conditions.

Section V – Reactivity Data

Stability:	Stable
Incompatibilities:	Aluminum, organic materials, acid chlorides, acid anhydrides, magnesium, copper. Avoid contact with acids and hydrogen peroxide > 52%.
Hazardous Decomposition of Byproducts:	Toxic fumes
Hazardous Polymerization:	Will not occur.

Section VI – Health Hazard Data

Routes of Entry:	**Inhalation:**	Highly unlikely
	Ingestion:	May be fatal if swallowed.

Skin:	The electrolyte (potassium hydroxide) is corrosive; skin contact may cause irritation or chemical burns.
Eyes:	The electrolyte (potassium hydroxide) is corrosive; eye contact may cause irritation or severe chemical burns.
Acute Effects:	The electrolyte is harmful if swallowed, inhaled or adsorbed through the skin. It is extremely destructive to tissue of the mucous membranes, stomach, mouth, upper respiratory tract, eyes and skin.
Chronic Effects:	Prolonged exposure with the electrolyte has a destructive effect on tissue. Chronic exposure to lead may cause disease of the blood and blood forming organs, kidneys and liver, damage to the reproductive systems and decrease in fertility in men and women, and damage to the fetus of a pregnant woman. Chronic exposure from the lead contained in this product is extremely unlikely.

Signs and Symptoms of Exposure:	Contact of electrolyte with skin or eyes will cause a burning sensation and/or feel soapy or slippery to touch. Other symptoms of exposure to lead include loss of sleep, loss of appetite, metallic taste and fatigue.
Carcinogenicity:	Lead is classified by the IARC as a class 2B carcinogen (possibly carcinogenic to humans)
OSHA:	Where airborne lead exposures exceed the OSHA action level, refer to *OSHA Lead Standard 1910.1025*.
NTP:	na
Medical Conditions Generally Aggravated by Exposure:	Lead exposure may aggravate disease of the blood and blood forming organs, hypertension, kidneys, nervous and possibly reproductive systems. Those with preexisting skin disorders or eye problems may be more susceptible to the effects of the electrolyte.
Emergency First Aid Procedures:	In case of contact with the skin or eyes, immediately flush with plenty of water for at least 15 minutes and remove all contaminated clothing. Get medical attention immediately. If ingested, give large amounts of water and DO NOT INDUCE VOMITING. Obtain medical attention immediately. If inhaled, remove to fresh air and obtain medical attention immediately.

Section VII – Precautions for Safe Handling and Use

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 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, wear eye and hand protection.
Cleanup Procedures:	Wipe down the area several times with a wet paper towel. Use a fresh towel each time. Contaminated paper towels are considered hazardous waste.

Section VIII – Control Measures

Eye Protection:	Chemical splash goggles
Hand Protection:	Rubber gloves
Other Protective Clothing:	Apron, face shield
Ventilation:	na

Section IX – Disposal

Both lead and potassium hydroxide are considered poisonous substances and are regulated under TSCA and SARA Title III.

EPA Waste Number:	D008
California Waste Number:	181
DOT Information:	RQ Hazardous Waste Solid N.O.S. (Lead), 9, UN3077, PG III
	Follow all Federal, State and Local regulations.

Section X – References

Material Safety Data Sheets from J.T. Baker Chemical, Aldrich, Malinckrodt, ASARCO
U.S. Department of Labor form OMB No. 1218-0072
Title 8 California Code of Regulations
TSCA
SARA Title III
CFR 49
CFR 29
CFR 40

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