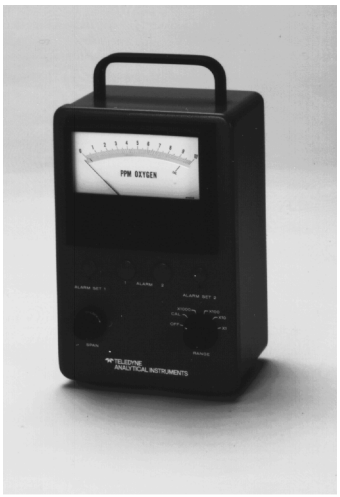
INSTRUCTION MANUAL

FOR

TRACE OXYGEN ANALYZER

MODEL 311



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WARNING

The sensor(s) used in this instrument 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.

SKIN CONTACT:	Flush contact area with cold water for several minutes. Seek medical attention.
EYE CONTACT:	Flush with cold water for at least 15 minutes. Seek immediate medical attention.
IF SWALLOWED:	Drink milk or milk of magnesia. Seek immediate medical attention.
IF INHALED:	Move immediately to an area of fresh air, or assist victim to fresh air. If victim is having difficulty breathing, use artificial respiration or administer oxygen. Seek immediate medical attention.

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TRACE OXYGEN ANALYZER

1. INTRODUCTION

1.1 Description: The Teledyne Analytical Instruments (TAI) Model 311 is a portable, intrinsically safe trace oxygen analyzer which can be operated without an external power source and reliably calibrated without the use of cumbersome, questionable, so-called "certified" calibration gases.

The instrument provides for trace oxygen analysis in decade steps ranging from 0-10 to 0-10,000 ppm (full scale) plus a special calibration range that encompasses the known oxygen concentration of atmospheric air (209,000 ppm).

Sample oxygen is read from an extremely accurate integral meter (0.5% linearity) whose range of measurement is determined by the position of the range selector switch. The 100 division meter scale and the multiplying factor indicated by the position of the range switch determine the full scale oxygen sensitivity of the instrument. The linear 5 inch scale (mirror equipped to eliminate parallax) provides excellent resolution and accuracy.

Sample gas is introduced and vented via a pair of quick disconnect fittings that feature integral shutoff valves which automatically close when the mating male fitting is withdrawn. The fittings are an integral part of the measuring cell manifold so that internal sample passage volume is at an absolute minimum. Sample flow control, although not critical (0.1 to 10 liters/min.) must be accomplished with accessory equipment.

1.2 Method of Analysis. The sample oxygen is measured by a unique electrochemical transducer which functions as a fuel cell; in this instance, the fuel is oxygen. Oxygen diffusing into the cell reacts chemically to produce an electrical current that is proportional to the oxygen concentration in the gas phase immediately adjacent to the transducer's sensing surface. The linear, but minute, signal produced by the transducer from trace oxygen is amplified by a two stage amplifier. The dual stages of amplification provide enough gain to drive the 0-100 microampere meter and thermistor controlled network utilized to compensate for the positive temperature co-efficient of the transducer.

1.3 Outstanding Features. The following unique features are incorporated into the Model 311:

1.3.1 Micro-Fuel Cell: 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 merely thrown away and replaced, as one would replace a worn out battery in a

flashlight. The life of the cell is warranted by TAI (see Section 4.4) in a fashion similar to that employed by the manufacturers of automobile batteries. This procedure guarantees the customer compensation for failure of a given cell to perform as specified.

1.3.2 Reliable Calibration. The unique qualities of the Micro-Fuel Cell allows the user to calibrate the instrument with the most economical, reliable, abundant, standardization gas there is -- atmospheric air.

The special "CAL" range of the instrument features a mark that coincides with the 209,000 ppm oxygen concentration of air. By drawing air through the instrument (see the Sample Calibration Procedure in Section 3.2) reliable calibration can be achieved.

After the electronics have been properly zeroed (a one-time factory operation), the instrument cannot produce an output indication in the absence of oxygen; therefore, the need for a "zero" standardization gas is obviated (Refer to Section 5 if readjustment is required).

1.3.3 Integral Power Supply. The differential power requirement (plus a minus 3.6 volts D.C.) of the instrument amplifier is furnished by two internally mounted 750 milliampere hour nickel cadmium batteries. Fully charged, these batteries will provide enough power to operate the instrument continuously for a period of about thirty-five (35) days. Furthermore, an overnight charge on a one-month duty cycle should keep the original batteries supplied usable for many years.

An integral charging circuit and a detectable power cord are provided so that the batteries may be recharged from any 50 or 60 cycle, 105 to 125 volt, convenience outlet.

The instrument is designed to either sample or have its batteries recharged. Both operations cannot be carried out simultaneously. TAI has deliberately interlocked the circuitry so that both operations cannot be carried on at the same time.

Only when the selector switch is placed in the OFF position will the neon lamp on the back plate of the Model 311 light up to indicate power to the battery charging circuit.

* U.S. Pat. Nos. 3,767,552 and 3,668,101

A current limiting resistor (R1 and R2) is potted into the end of each battery. This assures that under no circumstances can more than 25 milliamperes (100 milliwatts) be switched or drawn from either battery supply. This means that the Model 311-C may be used in explosive atmospheres where arcs of 100 milliwatts or less can be tolerated. The Model 311 meets Factory Mutual approval requirements as intrinsically safe for Class I, Division I, Groups A, B, C and D hazardous locations.

This safety feature does not apply when the instrument is being charged (AC power cord connected and selector switch in the "OFF" position). The instrument should not be used in explosive atmospheres when the batteries are being charged.

To determine the state of the rechargeable batteries turn the range selector knob counterclockwise to the battery test position and hold there (spring loaded switch). Observe that the meter indicator stays within the battery limits, *if not, recharge of the batteries is in order). Release Range Selector Switch, it will automatically return to the OFF position.

1.3.4 Accuracy and Response. The Model 311 provides monitoring accuracy of ±2% of full scale or ±1 ppm, whichever is greater, at constant temperature. A ±5% of reading accuracy is achievable throughout the operating temperature range of 30 to 125 Deg. F.

With a sample flowrate of 150 cc/min. 90% response is achieved in 10 seconds in the X10, X100, X1000, and CAL range switch positions. When in the X1 (0-10 ppm) range, 90% response is realized in 61 seconds.

1.3.5 Compact Packaging. The instrument is housed in a 6-1/8" X 9-1/2" X 5-5/8" aluminum case that is equipped with a carrying handle and foot pads. When in use, the analyzer should be placed in an upright position on a level surface (off level positioning will detract from meter accuracy).

Access to the instrument interior is gained by loosening (ccw) the three (3) 1/4 turn screw driver type fasteners on the back of the outer case. The case may then be detached from the driver type fasteners on the back of the outer case. The case may then be detached from the control of the outer case. The case may then be detached from the control panel assembly. Further disassembly may be accomplished by removing the back plate assembly from its four (4) mounting standoffs and laying the two separated assemblies out as illustrated on the "Analyzer Wiring Diagram". The diagram is included among the drawings at the rear of the manual.

2. SUPPORTING EQUIPMENT AND SERVICES

2.1 Sampling Equipment. The customer must provide a means of controlling the pressure and flowrate of the sample gas. For positive pressure applications, TAI suggests a simple throttle valve installed in the sample line between the sample point and the analyzer. The flowrate should be limited to between 0.1 and 10 liters/min.

IMPORTANT: If a pressure regulator is necessary or desirable, it must have a metallic diaphragm. Regulators with organic or plastic diaphragms are permeable to oxygen and, if used in the sampling system, will lead to high oxygen readings.

For atmospheric pressure sampling, connect a pump and flow control valve downstream from the analyzer and draw (rather than push) the sample through the instrument.

TAI supplies three (3) male disconnect fittings with the instrument. One for installation of the customer's sample line; one to be used to open the vent fitting of the instrument, and one (equipped with a plastic tube) for drawing air through the unit for calibration purposes.

2.2 Power Service. A source of single phase, 105 to 125 volt, 50 or 60 Hertz power, capable of delivering a maximum of 1/4 ampere of current will be periodically required to recharge the instrument's battery power supply. An eight (8) foot, UL approved, 3-wire detachable power cord is provided with the instrument and should be stored in a safe place when not in use. As a no cost option the 311 can be furnished with 220 volt, 50 or 60 Hertz charging power.

3. OPERATION

3.1 Introduction. The Model 311 is supplied completely assembled and ready for instant use. The Micro-Fuel Cell is in place within the manifold, and prior to shipment the manifold was purged with an inert gas to eliminate all but traces of oxygen from the internal sampling system. The integral shut-off valves in the quick disconnect sample fittings, if not disturbed, will maintain this inert atmosphere within the manifold indefinitely. This can be demonstrated by advancing the range selector switch to the X100 (0-1,000 ppm) position.

When the range selector is advanced from the "OFF" position, power to the instrument's circuitry is established. The meter will constantly respond to the residual oxygen within the integral sample passages.

It is impossible to achieve a "perfect" seal of the internal sample system, and what the meter is indicating is the diffusion -- consumption balance point of internal sample system and the Micro-Fuel Cell.

This "balance" point, with a properly calibrated instrument is always within the limits of the X100 range. If the reading climbs off the limits of this scale, a leak in the manifold assembly is indicated.

TO EXTEND CELL LIFE AND MINIMIZE THE TIME REQUIRED TO MAKE THE NEXT ANALYSIS, THE INSTRUMENT SHOULD ALWAYS BE PURGED WITH THE SAMPLE OR AN INERT GAS PRIOR TO BEING TAKEN OUT OF SERVICE FOR STANDBY OR STORAGE.

3.2 Calibration. The inherently constant output of the cell during its useful life precludes a definitive calibration cycle. TAI feels that the interval between calibrations should be dictated by the customer's application. If the instrument is being used to certify the oxygen content of a product for delivery, then, a calibration prior to certification would certainly be in order. If, on the other hand, the instrument is being used to monitor or guard a sample and the evidence provided by the analyzer will in themselves determine when a calibration check is in order. **The sensitivity of the analyzer should be checked at two to four week intervals**.

DO NOT CALIBRATE THE INSTRUMENT UNLESS THERE IS A TRACE OXYGEN GAS READILY AVAILABLE FOR PURGING IMMEDIATELY FOLLOWING THE CALIBRATION PROCEDURE.

3.2.1 Air Calibration Procedure. Employ the following step by step procedure to calibrate the instrument.

1) Stand the instrument upright on a level surface, and with the range switch in the "OFF" position, check the alignment of the meter pointer with the zero mark on the scale. Use the mirror to eliminate parallax, and adjust the screw on the face of the meter, if necessary, until the pointer and zero mark are in precise coincidence.

2) Advance the range switch to the "CAL" position.

3) Install the plastic tube equipped male disconnect fitting in either of the analyzer's sample ports, and a blank disconnect fitting in the other port (direction of sample flow is of no importance). A pump is recommended on the plastic tube. Pump the tube until the meter reading is stable.

<u>CAUTION</u>: DO NOT SUCK ON THE TUBE WITH YOUR MOUTH, THERE IS A POSSIBILITY THE MICRO-FUEL CELL MAY LEAK. THE CELL CONTAINS KOH SOLUTION WHICH IS CAUSTIC AND EXTREMELY HAZARDOUS!

4) Unlock and adjust the span control until the meter pointer is in coincidence with the "CAL" mark on the meter scale. **BE SURE TO RELOCK THE CONTROL AFTER THE ADJUSTMENT IS MADE.**

5) Immediately after Step 4 has been accomplished, disconnect the tubing equipped calibration fitting, and plug in either the sample or a source of inert gas.

If the instrument is to be used for sampling after the calibration procedure has been completed, follow the decreasing oxygen reading by positioning the range switch so that the meter gives the best possible resolution of the oxygen. **DO NOT ATTEMPT TO ACTUALLY TAKE A READING UNTIL THE METER INDICATION STABILIZES**. If the sample oxygen content lies within the limits of the X1 range (0-10 ppm), an overnight purge is recommended for the instrument to recover sufficiently from the effects of the 209,000 ppm oxygen concentration of air (over four decades of range differential). Recovery time is proportionally less the coarser ranges.

If, on the other hand, the instrument is not to be used immediately after calibration, and a low ppm oxygen gas is being employed as a purge, allow the manifold to be purged overnight, and then disconnect both male fittings. **ALWAYS DISCONNECT THE SOURCE FITTING FIRST, AND IMMEDIATELY THEREAFTER, THE VENT FITTING.**

3.2.2 Standard (Span) Gas Calibration (optional)

Gas required:

- Zero gas
- (70-90%) of full scale of the primary (working) range

NOTE: If the primary (working) range is a lower range, when you change to a higher range recalibration is a must for accuracy (see Figure 2 Chart, included).

1. Stand the instrument upright on a level surface, and with the range switch in the "OFF" position, check the alignment of the meter pointer with the zero mark on the scale, use the mirror to eliminate parallax and adjust screw on the face of the meter, if necessary, until the pointer and zero mark is in precise coincidence.

2. Install a sensor.

3. Install quick disconnect, **FIRST TO THE VENT** then the sample inlet.

4. Purge the analyzer with a zero gas for 12-16 hours at 2 SCFH.

5. Advance the range to CAL.

6. Connect span gas.

7. Advance the range when oxygen level is decreasing, wait until the reading stabilizes.

8. Unlock and adjust span control until the meter reads the oxygen content.

9. Advance the range to CAL.

10. Disconnect the span gas.

11. Connect the sample gas.

12. Advance the range when the oxygen level is decreasing, so that the meter gives the best possible resolution of the oxygen. DO NOT attempt to take a reading until the meter indicator stabilizes.

3.3 Positive Pressure Sampling. When connecting the instrument to a positive pressure sample source, ALWAYS proceed as follows:

1) Before making any connections to the instrument, establish a flowrate in the sample line of from 0.1 to 10 liters/min. Allow the sample to vent to accomplish long enough to purge the line free of air.

2) Install the vent fitting first, and then the sample source fitting. Be prepared to make the connections in rapid order, so that atmospheric diffusion time through the vent fitting is held to a minimum.

When disconnecting the instrument, reverse the procedure: source fitting first, and then vent fitting.

The objective of the connection -- disconnection procedure is to obviate the possibility of pressurizing the manifold. **IF A FLOWING SAMPLE WAS CONNECTED TO THE MANIFOLD WITHOUT THE VENT FITTING IN PLACE, THE PRESSURE IN THE MANIFOLD WOULD RISE AND BE EQUAL TO THE SAMPLE PRESSURE ALMOST IMMEDIATELY**. In such a situation, depending on the magnitude of the sample pressure, leaks in the manifold might result.

3.4 Atmospheric Pressure Sampling. If the sample is at atmospheric pressure (or slightly negative), a sample pump will be required downstream from the analyzer. The inlet side of the pump should also be equipped with a throttle valve -- so that sample flow can be reduced to between 0.1 and 10 liters/min. If pump loading is a consideration, the inlet side of the pump will have to include a bypass path that is open to the atmosphere through still another throttle valve. The sample path and bypass path may then be balanced by manipulating the two valves, so that sample flow is within the prescribed limits without loading the pump.

UNDER NO CIRCUMSTANCES SHOULD THERE BE ANY RESTRICTIONS IN THE LINE BETWEEN THE SAMPLE POINT AND THE ANALYZER -- as a partial vacuum would then be drawn on the cell. Since the cell is a partial pressure sensitive device, any oxygen readings taken under these conditions would be erroneous and vacuums in excess of one-third of an atmosphere may damage the cell.

4. MAINTENANCE

4.1 Battery Power Supply Service. The Model 311 is designed to be intrinsically safe, and therefore is for use ONLY when it is not connected to the AC power line. TAI suggests that an overnight recharge be accomplished every four (4) weeks of continuous use. To recharge the batteries, place the range switch in the "OFF" position and connect the power cord to a convenient outlet. **NOTE:** *The amber charge lamp (back of case) will be lit during charging. The integral charging circuit will automatically energize and regulate the battery charging current when the switch is in the "OFF" position and the AC cord is plugged into the power line.*

WARNING: DO NOT TURN THE RANGE SWITCH EITHER TO "BATT TEST" OR TO ANY OF THE OPERATING RANGE POSITIONS WHILE THE UNIT IS PLUGGED INTO THE POWER LINE! DOING SO MAY CAUSE THE INTEGRATED CIRCUITS TO FAIL.

When recharging is completed, unplug the unit from the AC outlet. Turn the range switch to the "BATT TEST" position or to the operating position.

NOTE: The "BATT TEST" position will not give a reliable indication of the battery charge immediately after a charge cycle. Allow the unit to run for awhile before testing the batteries.

If the instrument is stored with the range switch in the "OFF" position (charge cord disconnected), the period of time between charge periods is extended from one month to four months. However, do not leave it longer than this time period.

4.2 Routine Maintenance. Beyond adhering to a battery recharge schedule, no routine maintenance is required, as there are no moving parts in the instrument other than the meter movement. The Micro-Fuel Cell is a sealed, modular component that should be replaced only when faulty.

4.3 Cell Replacement. The characteristics of the Micro-Fuel Cell are similar to those of a mercury battery in that both provide an almost constant output through their useful life, and then fall off sharply towards zero at the end. If the sample being analyzed has a low (X1 range) oxygen concentration, cell failure will probably be indicated by the inability to properly calibrate the analyzer. The user will find that very little adjustment of the 10-turn span potentiometer will be required to keep the analyzer calibrated properly during the duration of a given cell's useful life. If large, many turn adjustments (cw) are required to calibrate the instrument, or calibration cannot be achieved within the range of the control, the cell should be immediately replaced (read Section 5.4 before replacing cell).

To offset the possibility of not having a replacement cell available when it is needed, TAI recommends that a spare cell be purchased shortly after the instrument is placed in service, and each time the cell is replaced thereafter.

The spare cell should be carefully stored in an area that is not subject to large variations in ambient temperature (75 Deg. F nominal), and in such a way as to obviate any possibility of incurring damage. Under no circumstances, disturb the integrity of the cell package until the cell is to be actually used. If the cell package is punctured and air permitted to enter, the cell will immediately start to react to the presence of oxygen.

No tools are required to replace the cell in the instrument. Simply unscrew (ccw) the plug at the bottom of the analyzer and the cell will drop out of the manifold cavity.

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

Place the cell on the end of the manifold plug -- so that the sensing surface of the cell is in contact with the plug and the electrical contact plate end of the cell is facing upwards. Insert the cell and plug in the manifold cavity, and screw the plug back into place. Apply as much pressure as you can with your fingers, but use no tools.

After the cell has been installed, purge the instrument with an inert gas (or the sample), and then proceed as directed in Section 3.2.1.

4.4 <u>Cell Warranty</u>. The Class B-2C cell employed in the Model 311 is warranted for 80,000 percent-hours or six (6) months of service (whichever occurs first).

With regard to spare cells, service time starts when the cell is removed from its shipping package. The customer should stock only one spare cell per instrument at a time. Do not attempt to stock- pile spare cells.

The Model 311 should not be used in applications where CO_2 is a major component in the sample. Concentrations of 1,000 ppm or less will not effect the cell performance. The following page is a graph showing the effects of CO_2 on cell life.

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.

Customer's having warranty claims must return the cell in question to the factory for evaluation, after obtained an RMA number. If it is determined that failure is due to faulty workmanship or material, the cell will be replaced at no cost to the customer.

<u>WARNING</u>: Evidence of damage due to tampering or mishandling will render the cell warranty null and void.

5. TRANSDUCER AND TEMPERATURE COMPENSATION

The Micro-Fuel Cell has an inherent positive temperature coefficient, the effects of which have been minimized through the implementation of a calibrated thermistor compensation circuit.

Internal electronic calibration is accomplished by TAI. However, should there by any doubt concerning it, the following procedure can be used to recalibrate. Refer to Schematic.

1. Disconnect cell.
2. Move range switch to "CAL" position.
3. Adjust R1 (designated as R1 on Schematic B14463 and designated on the A1 PCB module assembly as R28) such that the output of A1, pin 6, measures between 0 and +0.5 mV, ideally +0.3 mV.
4. Adjust R2 (designated as R2 on Schematic B14463 and designated on the A3 PCB module assembly as R28) for 0 ± 1 mV at output of A3, pin 6.
5. Verify that the offset is the same on all ranges.
6. Re-connect cell.

6. LEAK TESTING

If a leak is suspected in the unit, **DO NOT ATTEMPT TO TIGHTEN THE DISCONNECT FITTINGS. THE FITTINGS ARE POTTED IN EPOXY AND TIGHTENING THEM WILL BREAK THE SEAL!.**

To check the leaks, TAI recommends one of the following procedures:

Procedure I:

1. Purge the instrument down as low as possible.
2. Place the vent line in water and disconnect the sample.
3. Next, disconnect the vent line and place the range switch on the X100 range.
4. The unit should stay on the X100 range if there are no leaks.

Procedure II:

1. Purge the instrument with Nitrogen at the sample port.
2. Note the reading once it has stabilized (at least 24 hrs. on the 0-10 ppm range) and increase the flow rate.
3. If the reading goes down, the unit, or the tubing to the unit, has a leak.

7. PRODUCT SPECIFICATION DATA

Ranges: 0-10, 0-100, 0-1000, 0-10000 ppm Oxygen
CAL range for air calibration

Sensitivity: 0.5% of Full Scale

Accuracy: ±2% of full scale (except ±1 ppm for 0-10 ppm range) at constant temperature and pressure (temperature and pressure of calibration).

±5% of full scale (except ±1 ppm for 0-10 ppm range), over operating temperature range (once temperature equilibrium has been achieved).

System Operating Temperature: 0-50° C

Response Time: 90% response time 61 seconds

Reproducibility: ±1% at constant temperature

Sensor Type: Class B-2C

System Power Requirements: Model 311 - AC power for battery recharge circuit of two current limited rechargeable NiCad batteries, 115 VAC, 50/60Hz (100/220 VAC optional).

Weight: 6 lb (2.71 Kg.).

Approval: Intrinsically Safe (Class I, DIV. I, GROUP A, B, C and D), Factory Mutual approved.

RECOMMENDED SPARE PARTS LIST

MODEL 311

QTY.	P/N	DESCRIPTION
1	F-51	MICRO-FUSE, 0.25 AMP., FAST-BLOW (FOR 210-240 VAC)
1	F-39	MICRO-FUSE, 0.25 AMP., FAST-BLOW (FOR 100-125 VAC)
1	C6689 -B2C	MICRO-FUEL CELL, CLASS B-2C
1	C6689-A2C	MICRO-FUEL CELL, CLASS A-2C (CO_2 applications)
2	B-9905	BATTERY
1	L-79	LAMP
1	M70	METER.
1	B-45773	DIAL-RANGE OF 0-10, 0-100, 0-1000, 0-10000 PPM O_2 & CAL. (USE WITH M70 METER)

A MINIMUM CHARGE IS APPLICABLE TO SPARE PARTS ORDERS.

IMPORTANT: Orders for replacement parts should include the part number (if available), model number, serial number, sales order number, and range/background of the analyzer for which the parts are intended.

SEND ORDERS TO:

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TEC. SUPPORT: (626) 934-1673
Web: www.teledyne-ai.com

DRAWING LIST

MODEL 311

B-9271	PICTORIAL DIAGRAM
C-14463	SCHEMATIC
C-14627	WIRING DIAGRAM

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