OPERATIONS MANUAL

MODEL 110P ANALYZER

gasanalyzers.com

California Analytical Instruments, Inc.

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Website: www.gasanalyzers.com

Table of Contents

Table of Figures

Tables

1. INTRODUCTION

1.1. Overview

Thank you and congratulations! You have just purchased one of the most reliable gas analyzers in the world. Before using the analyzer, please familiarize yourself with its operation by reading this manual. If you have any questions, please do not hesitate to call California Analytical Instruments for assistance. We want you to be a member of our thousands of satisfied customers.

1.2. Unpacking Instructions

Open the shipping container and carefully remove the analyzer from the packing materials. Inspect the instrument for any sign of damage. Remove the retaining screws and lift off the cover panel. Visually check for proper seating of parts and or connectors. If all internal components appear to be normal replace the cover and secure it with the screws previously removed.

1.3. Reporting Damage

Should there be any apparent damage either to the inside or outside of the instrument due to shipping or handling, notify the shipper immediately. Retain the shipping container or packing materials for inspection by the shipper.

1.4. Contact Information

California Analytical Instruments, Inc.
1312 West Grove Avenue
Orange, CA 92865
714 974-5560
Fax 714 921-2531
Website: www.gasanalyzers.com

1.5. *Warranty Certificate*

Subject to the exceptions and upon the conditions stated below, California Analytical Instruments (CAI) warrants that the products sold under this sales order shall be free from defects in workmanship and materials for one year after delivery of the product to the original Buyer by CAI and if any such product should prove to be defective within such one year period, CAI agrees, at its option, either (i) to correct by repair or, at CAI's election, by replacement with equivalent product any such defective product, provided that investigation and factory inspection discloses that such defect developed under normal and proper uses, or (ii) to refund the purchase price. The exceptions and conditions mentioned above are as follows:

a) components or accessories manufactured by CAI that by their nature are not intended to or will not function for one year are warranted only to give reasonable service for a reasonable time. What constitutes reasonable time and reasonable services shall be determined solely by CAI. A complete list of such components and accessories is maintained at the factory;

b) CAI makes no warranty with respect to components or accessories not manufactured by it; in the event of defect in any such component or accessory CAI will give reasonable assistance to Buyer in obtaining from the respective manufacturer whatever adjustment is authorized by the manufacturer's warranty;

c) any product claimed to be defective must be returned to the factory transportation charges prepaid and CAI will return the repaired or replaced product freight collect;

d) if the product claimed to be defective requires on-site repair, such warranty labor will be provided at no charge; however, transportation and living expenses will be charged to Buyer;

e) if the product is a consumable or the like, it is warranted only to conform to the quantity and content and for the period (but not in excess of one year) stated on the label at the time of delivery or 90 days;

f) CAI may from time to time provide a special printed warranty with respect to a certain product, and where applicable, such warranty shall be deemed incorporated herein by reference;

g) CAI shall be released from all obligations under all warranties, either expressed or implied, if any product covered hereby is repaired or modified by persons other than its own authorized service personnel unless such repair by others is made with the written consent of CAI.

IT IS EXPRESSLY AGREED THAT THE ABOVE WARRANTY SHALL BE IN LIEU OF ALL WARRANTIES OF FITNESS AND OF THE WARRANTY OF MERCHANTABILITY AND THAT CAI SHALL HAVE NO LIABILITY FOR SPECIAL OR CONSEQUENTIAL DAMAGES OF ANY KIND OR FROM ANY CAUSE WHATSOEVER ARISING OUT OF THE MANUFACTURE USE, SALE, HANDLING, REPAIR, MAINTENANCE OR REPLACEMENT OF ANY OF THE PRODUCTS SOLD UNDER THIS SALES ORDER. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THAT THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY HAVE OTHER RIGHTS, WHICH VARY FROM STATE TO STATE.

Representations and warranties made by any person, including dealers and representatives of CAI which are inconsistent or in conflict with the terms of this warranty, shall not be binding upon CAI unless produced in writing and approved by an expressly authorized officer of CAI.

2. FEATURES AND PRINCIPLES OF OPERATION

2.1. Description

The Paramagnetic Oxygen Analyzer (PMA) is a thermostated instrument designed primarily for, but not necessarily limited to, stationary use. It is a '19" rack mount' analyzer that is also suitable for bench top use. The operation of the analyzer is based upon the principle of the magneto-dynamic oxygen cell, which is the most accurate and reliable cell for determining the oxygen content of a gas mixture from 0-100 volume percent oxygen.

Warning: This is a general-purpose analyzer, not suitable for hazardous areas. High-pressure oxygen is very dangerous. Virtually any material will burn in it, possibly explosively. It is essential that all persons using this analyzer are aware of the dangers of oxygen, and take all appropriate precautions.

2.2. Product Specifications Model 110P (Paramagnetic Detector)

SAMPLE CONTACT MATERIAL: Platinum. glass, stainless steel, Viton, Teflon* and Tygon**

RANGES: Standard fixed ranges, either A or B or C

A) Range 1: 0 to 1%; Range 2: 0 to 15%; Range 3: 0 to 25%

B) Range 1: 0 to 5%; Range 2: 0 to 10%; Range 3: 0 to 25%

C) Range 1: 0 to 25%; Range 2: 0 to 40%; Range 3: 0 to 100%

RESPONSE TIME: 90% full scale in 2 seconds

NOISE: Less than 1% full scale

LINEARITY: Better than 1% full scale

REPEATABILITY: Better than 1% full scale

ZERO SPIN DRIFT: Less than 1% full scale in 24 hours

ZERO & SPAN ADJUSTMENT: Ten turn potentiometer

DISPLAY: 3 ½" digit panel meter

OUTPUTS: 0 to 10 VDC and 4 to 20 mA (0 to 20 mA)

AMBIENT TEMPERATURE: 5 to 45° C

SAMPLE TEMPERATURE: 0 to 50° C

SAMPLE CONDITION: Particles < 1µ, non-corrosive dry gas

FITTINGS: ¼" tube

SAMPLE FLOW RATE: 0.5 –2.0 LPM

Power Requirements: 115/230 (± 10%) VAC, 50/60 Hz, 70 watts/channel

Relative Humidity: Less than 90% R.H.***

WEIGHT: 15 lbs. (6.8 kg)

Dimensions: 5 ¼" H x 19" W x 15" D (133 mm H x 483 mm W x 381 mm D)

Specifications subject to change without notice

*Viton and Teflon are trademarks of DuPont

**Tygon is a registered trademark of the Norton Performance Plastics Corp.

***Non-condensing

2.3. Principle of operation

The paramagnetic susceptibility of oxygen is significantly greater than that of other common gases, and consequently, a magnetic field attracts the molecules of oxygen more strongly than the molecules of the other gases. Most other gases are slightly diamagnetic, which means that a magnetic field repels their molecules.

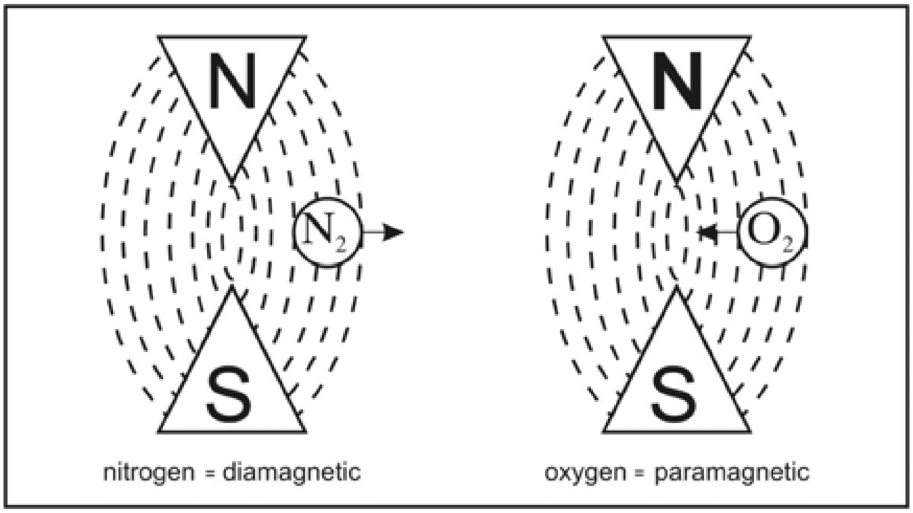

Figure 2-1 Magnetic Susceptibility of gases

Faraday's method of determining the magnetic susceptibility of a gas is the principle of the magneto dynamic cell. The measuring cell includes a dumbbell made of two nitrogen-filled quartz spheres suspended in a symmetrical non-uniform magnetic field. Placed around the center beam of the dumbbell is a feedback coil made of single turn of platinum wire.

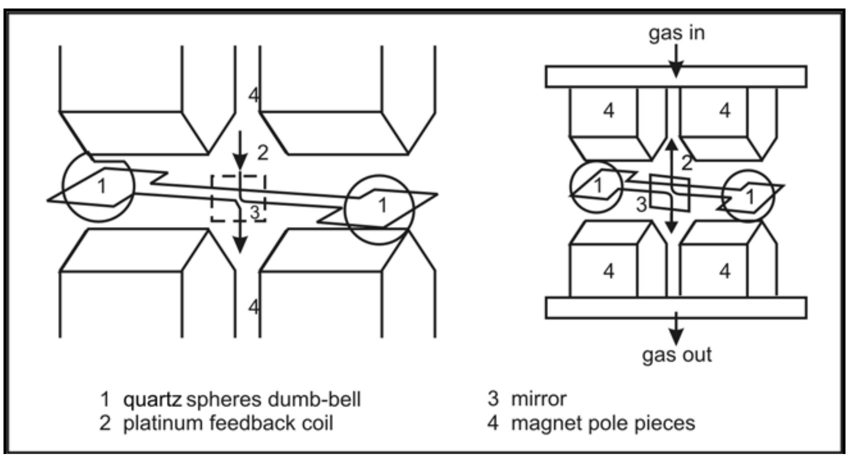

Figure 2-2 The Measuring cell in theory

When the sample gas contains oxygen, the relatively strong paramagnetic oxygen causes a change in the magnetic field and pushes the dumbbell spheres out of the magnetic field. The oxygen concentration is proportional to the torque acting on the dumbbell.

The distortion of the dumbbell is sensed by a light beam and projected on a mirror attached to the dumbbell and is reflected to a pair of photocells. Equal illumination of both photocells results in zero output. The output from the photocells connects to an amplifier that connects to the feedback coil of the measuring cell. If the oxygen content of the gas sample changes, the corresponding current output of the amplifier, which is proportional to the oxygen content, produces a magnetic field in the feedback coil opposing the forces and thereby causing the dumbbell to rotate.

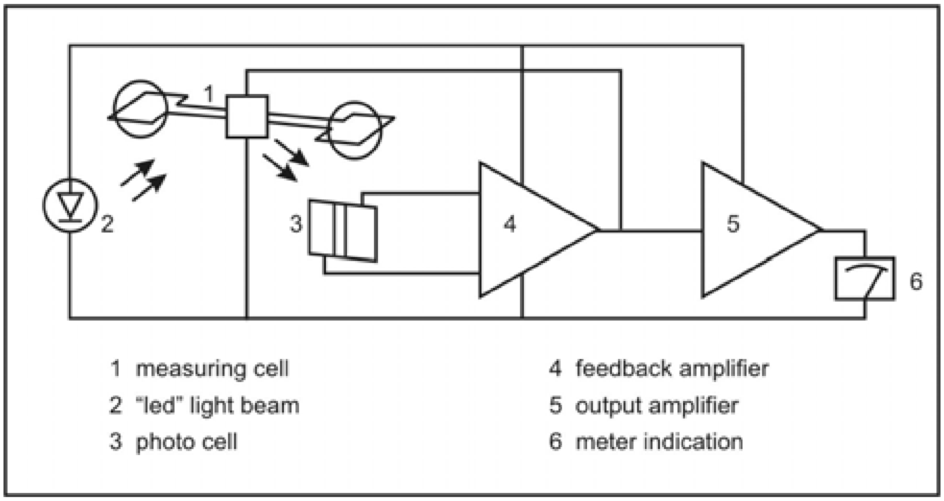

Figure 2-3 Principle of operation

Since the feedback current from the amplifier is proportional to the oxygen content of the gas sample, the output signals produced by the amplifier will be accurate and linear. The paramagnetic susceptibility of oxygen varies inversely as the square of the absolute temperature. To provide compensation for changes in analyzer temperature, a temperature sensitive element in contact with the measuring cell assembly is included in the feedback current circuit

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3. INSTALLATION

3.1. General

The design of the instrument is for industrial applications. These installation instructions are for a typical site. Direct any questions regarding specific installation situations to Technical Service of California Analytical Instruments, Inc.

Warning: This is a general-purpose analyzer, not suitable for hazardous areas. High-pressure oxygen is very dangerous. Virtually any material will burn in it, possibly explosively. It is essential that all persons using this analyzer are aware of the dangers of oxygen, and take all appropriate precautions.

3.2. Site and Mounting

NOTE: Observe the following precautions carefully:

1) Select a site free from direct sunlight, radiation from a high temperature surface, or abrupt temperature variations.
2) This analyzer is not suitable for outdoor installation.
3) Select a site where the air is clean. Avoid exposing the instrument to corrosive or combustible gases.
4) The instrument must not be subject to severe vibration. If severe vibration is present, use isolation mounts.
5) The design of the instrument is for rack mounting. Optional rack mount slides are available.
6) Do not install near equipment emitting electromagnetic interference (EMI).

NOTE: A rear supporting brace or equivalent is required if the optional rack mount slides were not purchased.

3.3. Electrical

Connect all wiring at the rear of the instrument. Table 3-1 on the following page show the connect outputs, etc. Connect the AC power to the power/fuse/switch as shown below in Figure 3-1.

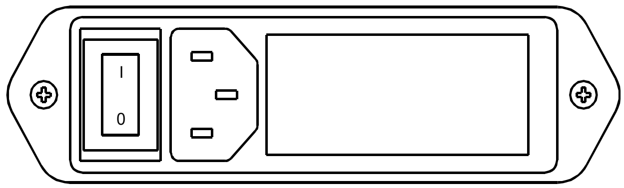


Figure 3-1 AC Power Switch, Connector, and Fuse.

NOTES: A defective ground may affect the operation of the instrument. Connect the output voltages per Table 3-1. Shielded wiring is recommended for output signals.

CAUTION: Electromagnetic interference (EMI) may affect the operation of the instrument. Do not install the instrument near electrical noise (such as high frequency furnaces, electric welding machines, etc.). Use a separate power line if installing the instrument at such locations. Control the noise from a relay or solenoid valve by the use of an EMI suppressor (RC circuit) across the power wiring close to the noise-generating component (see Figure 3-2).

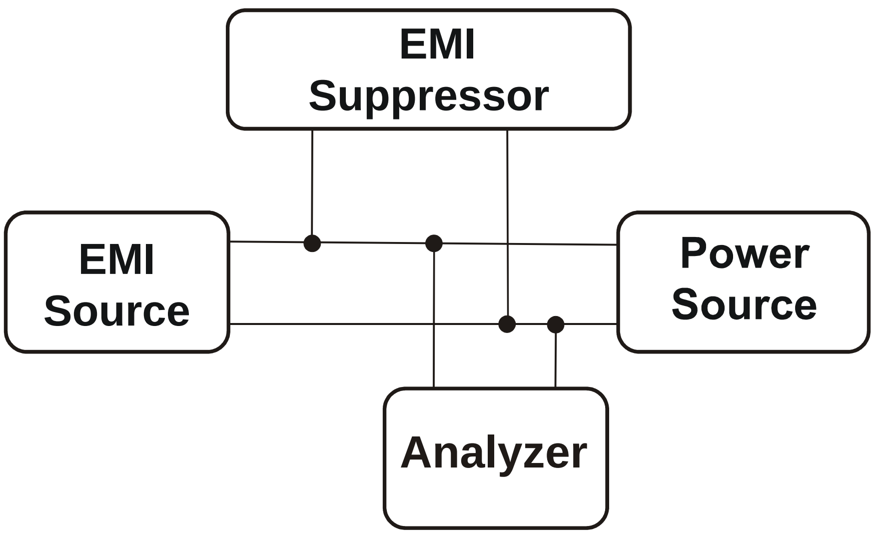


Figure 3-2 EMI Suppressor.

NOTE: Locate the EMI Suppressor close to the noise source.

Table 3-1 I/O Connections

Model 110P

Pin #	Outputs (Voltage or Current)
1	DC Common
2	
3	Positive (0-10 VDC)
4	DC Common
5	Positive (4-20 mA)
6	Not used
7	Sensor Temperature (10mv per degree C)
8	Not Used
9	Not Used
10	Not Used
11	Not Used
12	Not Used
13	Not Used
14	Not Used
15	Not Used
16	Not Used
17	Not Used
18	Remote Range 1 Control Input/Range 1 I.D. output
19	Remote Range 2 Control Input/Range 2 I.D. output
20	Remote Range 3 Control input/Range 3 I.D. output
21	Not Used
22	Not Used
23	Not Used
24	Not Used
25	Remote Mode I.D. Output
26	DC Common
27	+5 VDC Output
28	DC Common

3.4. Sampling System

Note: High-pressure oxygen is very dangerous. Virtually any material will burn in it, possibly explosively. It is essential that any person using this analyzer is aware of the dangers of oxygen, and take all appropriate precautions.

The analyzer's sampling system consists of:

1) An externally mounted in line particulate filter
2) A sample pump and flow meter (optional)
3) A sample capillary that controls the sample flow rate to the sensor at 200 cc's/min.
4) A precision controlled relief valve.

The relief valve maintains a constant inlet pressure to the sample capillary and reduces response time by providing a bypass loop to the exhaust for excess sample.

The design of the analyzer is to measure a conditioned clean dry sample gas. Removal of the moisture is to prevent condensation in the analyzer. Some applications may require additional sample conditioning, dependent upon the specifications of the measured sample gas.

3.5. Required Gases and Gas Handling Equipment

1) Nitrogen (zero gas) in pressurized cylinder.
2) Standard span gas(es) near full-scale concentration (typically 80-95% of the analyzers measuring range) with a nitrogen balance, in a pressurized, certified cylinder.
3) Pressure regulators for zero and span gas cylinders.
4) Corrosive resistant gas tubing.
5) Flow meter with valve (0-2 LPM) — if not supplied as an analyzer option.
6) Pump— if not supplied as an analyzer option.

3.6. Gas Connections

Use corrosive resistant material such as Teflon ® or stainless steel for the tubing from the sampling system to the gas analyzer. Do not use rubber or soft vinyl tubing even when the gases sampled are non-corrosive, since readings may be inaccurate due to gas absorption into the piping material. To obtain fast response, the tube should be as short as possible. Optimum tube internal diameter is 0.16 inch (4 mm). Instrument couplings are ¼-inch tube. A sample-gas outlet fitting is located on the rear panel (¼-inch tube Keep pressure at this outlet at atmospheric level. Vent this gas from the instrument.

NOTE: Be sure tubing and joints are clean. Dust entering the instrument may cause it to malfunction.

3.7. Sampling Requirements

1) Filtration
   a) Eliminate all dust.
   b) Use filters as necessary.
   c) The filter must be capable of removing particles larger than one micron.
2) Condensation
   a) Dew point of the sample gases must be lower than the ambient temperature to prevent accidental condensation within the instrument.
   b) When water vapor is present, pass the sample through a dehumidifier to reduce the dew point of the sample to less that ambient.
3) If the sample contains an acid mist, use an acid mist filter, cooler, or similar device to remove all traces of the mist.
4) Presence of Corrosive Gases
   - High concentrations of corrosive gases such as Cl2, F2, HCI, etc, shorten the useful service life of the instrument if they are present in the sample gas.
5) Gas Temperature
   - When measuring high temperature gases, ensure that the maximum rating of the instrument (122º F (50º C), is not exceeded.
6) Flow Rate
   - The gas entering the instrument should flow at a rate from 0.5 to 2.0 liters/min.

NOTE: Teflon® is a registered trademark of E. I. du Pont de Nemours and Company.

4. Description & Function of Components

Front panel zero and span controls provide for adjusting the output as necessary when flowing zero and span gases.

Mounted on the front panel is a four-position range switch that selects the desired measuring range. Range-one is the most sensitive range, while range-three is the least sensitive. The fourth position labeled RMT stands for remote. Use this position whenever an external device controls the analyzer measuring range.

4.1. Model 110P Analyzer Front Panel

Figure 4-1 Model 110P Analyzer Front Panel

1)	**Indicator Digital Display:** Displays output from the oxygen sensor and PCB in direct engineering units
2)	**Range Switch:** Used for measuring range selection
3)	**Zero Control:** Used for adjusting the zero level of the instrument while flowing zero gas
4)	**Span Control:** Used for adjusting span of the instrument while flowing span gas
5)	**Flow meter:** (Optional)
6)	**Pump Switch:** (Optional)

4.2. Model 110P Analyzer Rear Panel

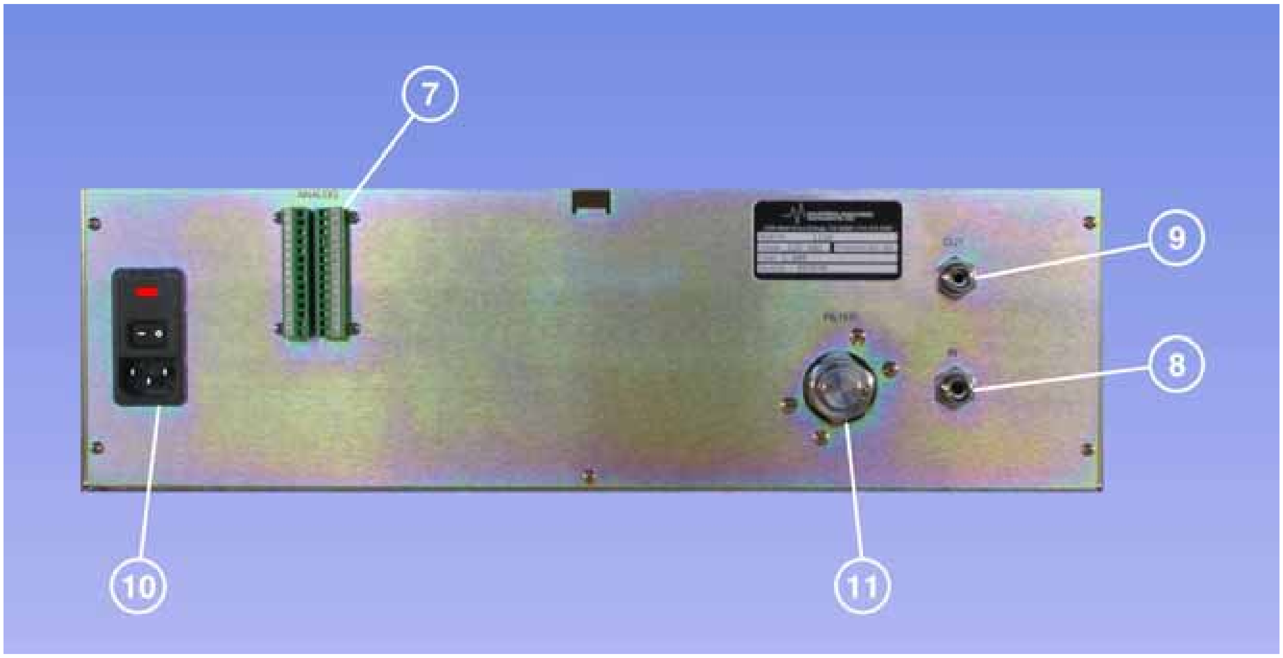


Figure 4-2 Model 110P Analyzer Rear Panel

7)	**Terminal Strip:**
	Control and Output Data
8)	**Sample Gas Inlet:**
	For introducing sample gas into the oxygen analyzer. (¼" tube)
9)	**Sample Gas Outlet:**
	For exhausting sample gas. (¼" tube)
10)	**Power Connector, On/Off Switch, Fuse**
11)	**Inlet Sample Filter**

4.3. Model 110P Interior Layout – With Sample Gas Pump

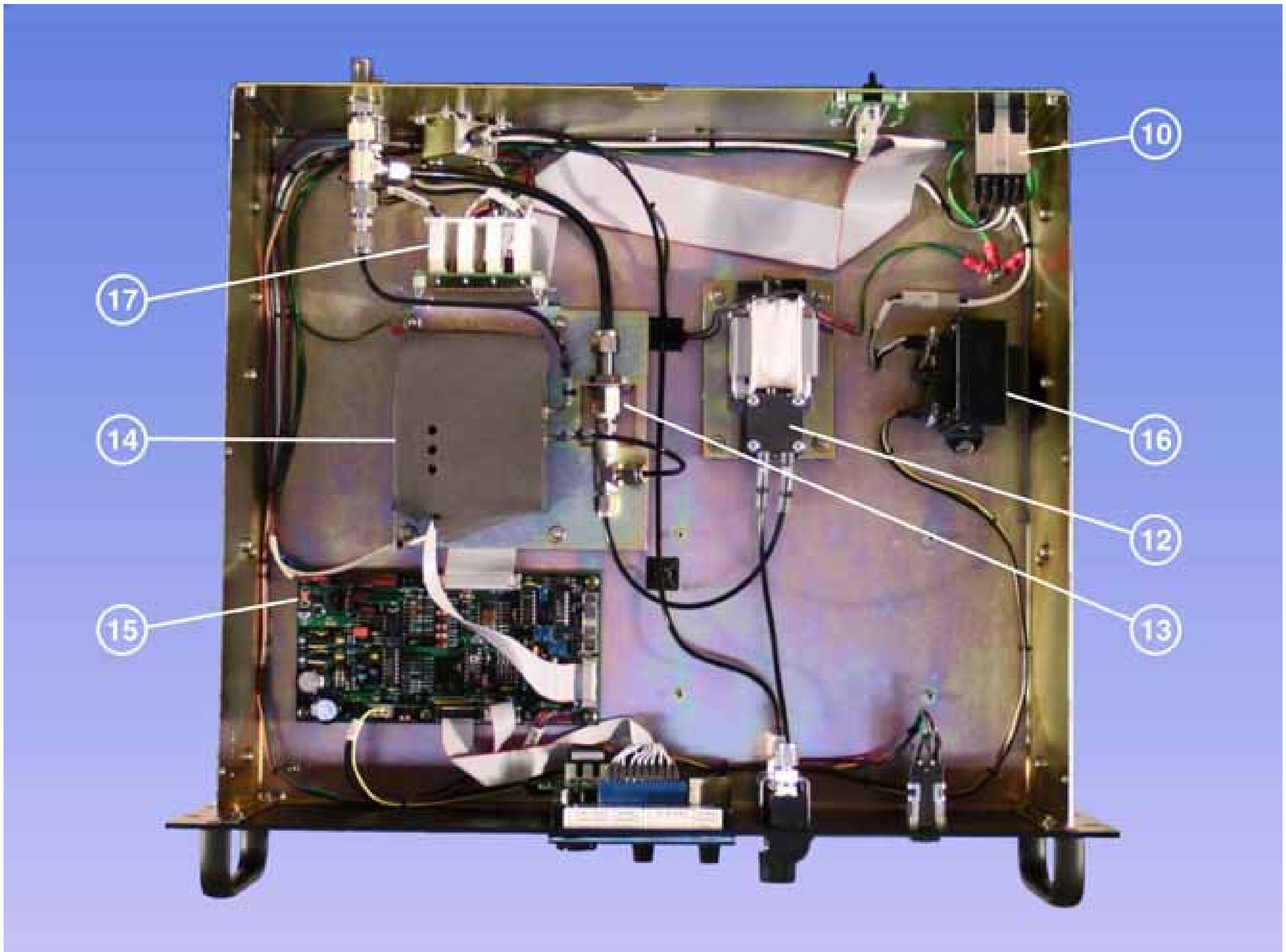


Figure 4-3 Model 110P Interior Layout – With Sample Gas Pump

10)	**Power Connector, On/Off Switch, Fuse**
12)	**Sample Pump:**
	(Optional)
13)	**Relief Valve.**
14)	**Paramagnetic Oxygen Sensor.**
15)	**Circuit Board for Paramagnetic O_2.**
16)	**Power Transformer.**
17)	**Relay Control-PCB.**

5. Preparations for Operation

Warning: This is a general-purpose analyzer, not suitable for hazardous areas. High-pressure oxygen is very dangerous. Virtually any material will burn in it, possibly explosively. It is essential that all persons using this analyzer are aware of the dangers of oxygen, and take all appropriate precautions.

1) External Wiring
   - Check the external wire connections as described in Section 3 installation.
2) External Piping
   - Review Section 3, 3-4 through 3-7.

5.1. Power on

Turn on the power switch on the rear panel. The digital panel meters should illuminate. Allow the instrument to warm up for approximately one hour. It is preferable, but not essential, to have zero gas flow through the instrument during warm up.

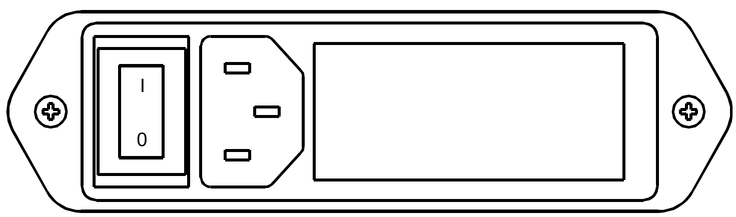


Figure 5-1 AC Power Switch, Connector, and Fuse.

NOTE: DO NOT introduce the sample gas UNTIL the analyzer has warmed-up. This will help prevent condensation from forming in the sample cell.

5.2. Zero Adjustment:

After the one-hour warm up period, flow zero gas (see Section 3.5 Gases) through the instrument at a rate of about 1 liter/min. Adjust the zero control on the front panel until the digital meter (or analog output) is exactly at zero. To achieve final stability, the analyzer may require some additional warm-up period of up to four hours (depending on variables in the analyzer's environment).

5.3. Span Adjustment:

Flow span gas through the instrument at about 1 liter/min. Adjust the span controls on the front panel until the digital meter or analog output is reading the value corresponding to the span gas concentrations.

Note: Span gas concentration should not be less than 80% of the span range.

Note: On the 0-25% range of the analyzer ambient air may be used as span gas. While ambient air is flowing to the analyzer, adjust the span potentiometer to 20.9% O_2.

5.4. Start-Up and Routine Maintenance:

Prepare and check the sample system. Adjust the flow of sample gas to about 1 L/min. The instrument should show a meter indication. The design of the paramagnetic oxygen analyzer is for extended operation and may be left switched ON continuously.

5.5. Cross sensitivity of gases

The very high magnetic susceptibility of oxygen is the basis of the paramagnetic measuring principle. In comparison to oxygen, other gases have such a minor susceptibility that most of them are insignificant. Exceptions to this are the nitrogen oxides. However, as these gases are in most cases present in a very low concentration, the error is still negligible.

Example 1

The residual oxygen percentage is measured in a closed carbon dioxide (CO_2) atmosphere. Nitrogen (N_2) is used for "zero calibration."

According to the list of cross-sensitivities, the error for 100 % CO_2 at 20^o C is 0.27%. In order to obtain a higher accuracy, this means that for the zero calibration the reading should be adjusted at +0.27% with N_2, in order to compensate the error of CO_2.

Since the values of cross-sensitivities are based on 100% volume of that particular gas, the error at 50% by volume CO_2 and 50% by volume N_2 is 0.135%.

Example 2

Given the following gas composition at a temperature of 20^o C:

5% volume Oxygen (O_2)	$+100.00 \times 10^{-2} \times 5$	=	+5.0000
40% volume Carbon Dioxide(CO_2)	$-0.27 \times 10^{-2} \times 40$	=	-0.1080
1% volume Ethane(C21-14)	$-0.43 \times 10^{-2} \times 1$	=	-0.0043
54% volume Nitrogen (N2)	$0.00 \text{ X } 10^{-2} \times 54$	=	0.0000
Gives a reading (% by volume) of:			+4.8877

As this example shows, the total error (5.000 minus 4.8877) is 0.1123.

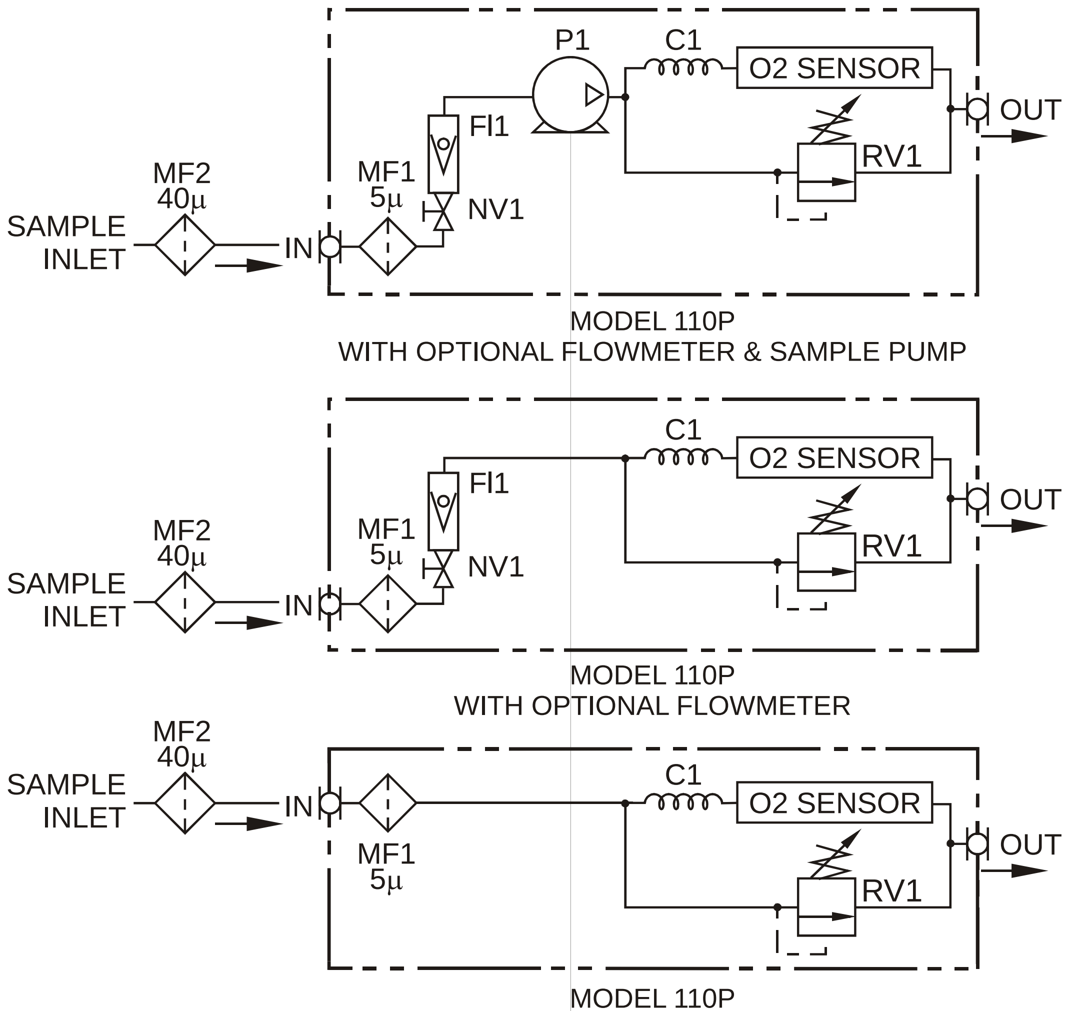
Note: see Table 4-1 below for cross sensitivity values of typical gases.

Table 5-1 Cross Sensitivity of gases

All values based on nitrogen 0% / oxygen 100%

Gas	Formula	20 °C	50 °C
Argon	Ar	-0.23	-0.25
Acetylene	C_2H_2	-0.26	-0.28
Acetone	C_3H_60	-0.63	-0.69
Acetaidehyde	C_2H_4O	-0.31	-0.34
Ammonia	N_3	-0.17	-0.19
Benzene	C_6H_4	-1.24	-1.34
Bromine	Br_2	-1.78	-1.97
Butadiene	C_4H_6	-0.85	-0.93
Isobutylene	$(CH_3)2CH=CH_2$	-0.94	-1.06
n-Butane	C_4H_{10}	-1.10	-1.22
Chlorine	CL_2	-0.83	-0.91
Hydrogen Chloride	HCL	-0.31	-0.34
Nitrous Oxide	N_2O	-0.20	-0.22
Diacetylene	$(CHCl)_2$	-1.09-	-1.20
Ethane	C_2H_4	-0.43	-0.47
Ethylene Oxide	$C_2H_4O_2$	-0.54	-0.60
Ethylene	C_2H_4	-0.20	-0.22
Ethylene Glycol	CH_2OHCH_2OH	-0.78	-0.88
Ethylbenzene	C_8H_{10}	-1.89	-2.08
Hydrogen Fluoride	HF	+0.12	+0.14
Furan	C_4H_40	-0.90	-0.99
Helium	He	+0.29	+0.32
n-Hexane	C_6H_{14}	-1.78	-1.97
Krypton	Kr	-0.49	-0.54
Carbon Monoxide	CO	-0.06	-0.07
Carbon Dioxide	CO_2	-0.27	-0.29
Methane	CH_4	-0.16	-0.17
Methanol	CH_4O	-0.27	-0.31
Methylene Chloride	CH_2Cl_2	-1.00	-1.10
Neon	Ne	+0.16	+0.17
n-Octane	C_8H_{18}	-2.45	-2.70
Phenol	C_6H_6O	-1.40	-1.54
Propane	C_3H_8	-0.77	-0.85
Propylene	C_3H_6	-0.57	-0.62
Propene	$CH_3CH=CH_{12}$	-0.58	-0.64
Propylene Oxide	C_3H_6O	-0.90	-1.00
Propylene Chloride	C_3H_7Cl	-1.42	-1.44
Silane	SiH_4	-0.24	-0.27
Styrene	$C_7H_6=CH_2$	-1.63	-1.80
Nitrogen	N_2	-0.00	-0.00
Nitrogen Monoxide	NO	+42.70	+43.00
Nitrogen Dioxide	NO_2	+5.00	+16.00
Oxygen	O_2	+100.00	+100.00
Sulfur Dioxide	SO_2	-0.18	-0.20
Sulfur Fluoride	SF_6	-0.98	-1.05
Hydrogen Sulfide	H_2S	-0.41	-0.43
Toluene	C_7H_8	-1.57	-1.73
Trichloroethylene	C_2HCl_3	-1.56	-1.72
Vinyl Chloride	C_2H_3Cl	-0.68	-0.74
Vinyl.Fluoride	CH_3F	-0.49	-0.54
Water	H_2O	-0.03	-0.03
Hydrogen	H_2	+0.23	+0.26
Xenon	Xe	-0.95	-1.02

6. Mechanical & Electrical Drawings



4. IN-LINE FILTER (MF2) CUSTOMER SUPPLIED.

3. INLET & OUTLET CONNECTIONS ARE 1/4” OD TUBE.

2. SAMPLE FLOW RATE: 0.5 – 2.0 LPM.

1. SAMPLE PRESSURE: 3-5 PSIG (NOT REQUIRED WITH OPTIONAL SAMPLE PUMP).

NOTES: UNLESS OTHERWISE SPECIFIED.

Figure 6-1 110P flow diagram

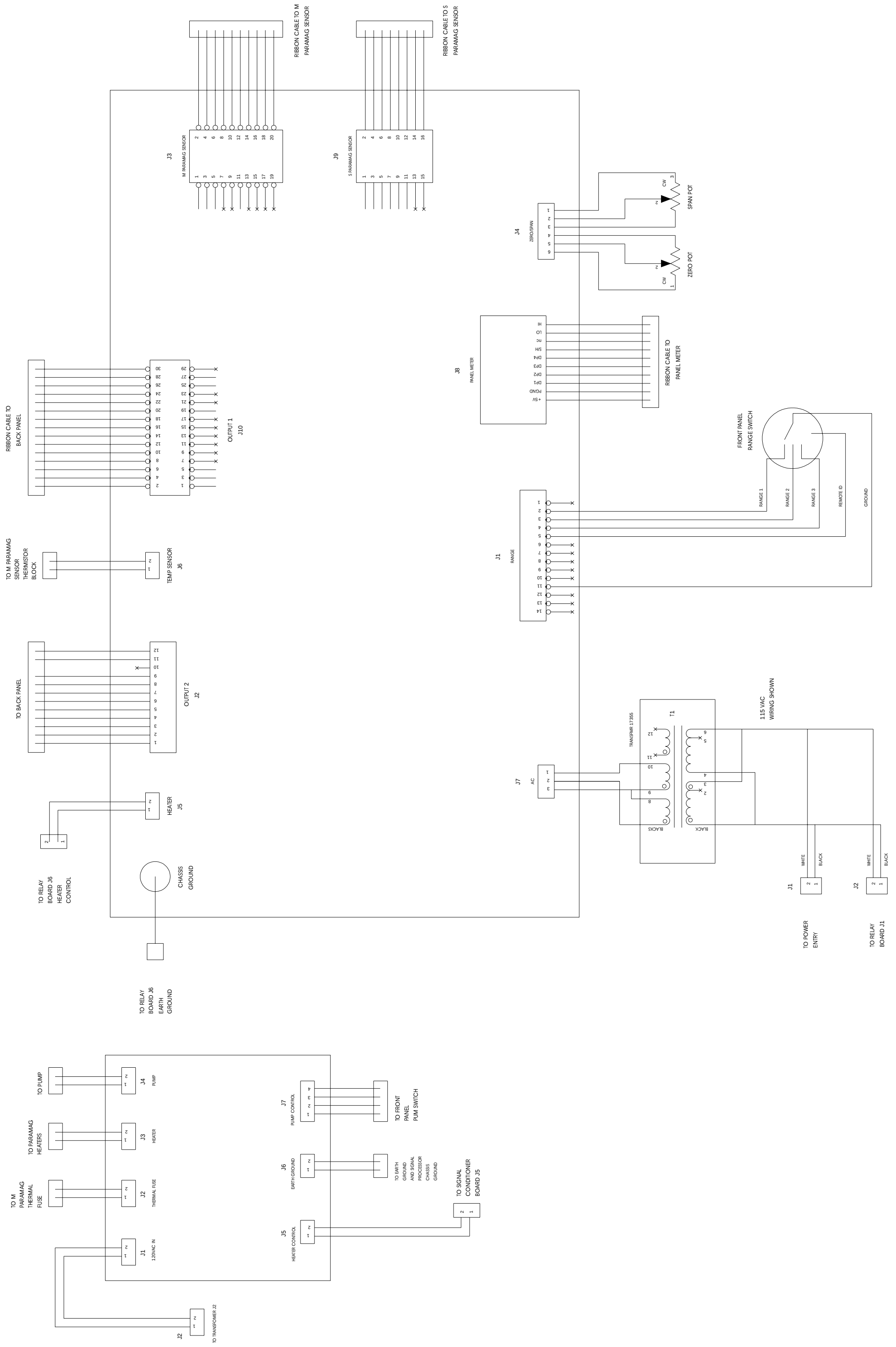


Figure 6-2 110P wiring diagram