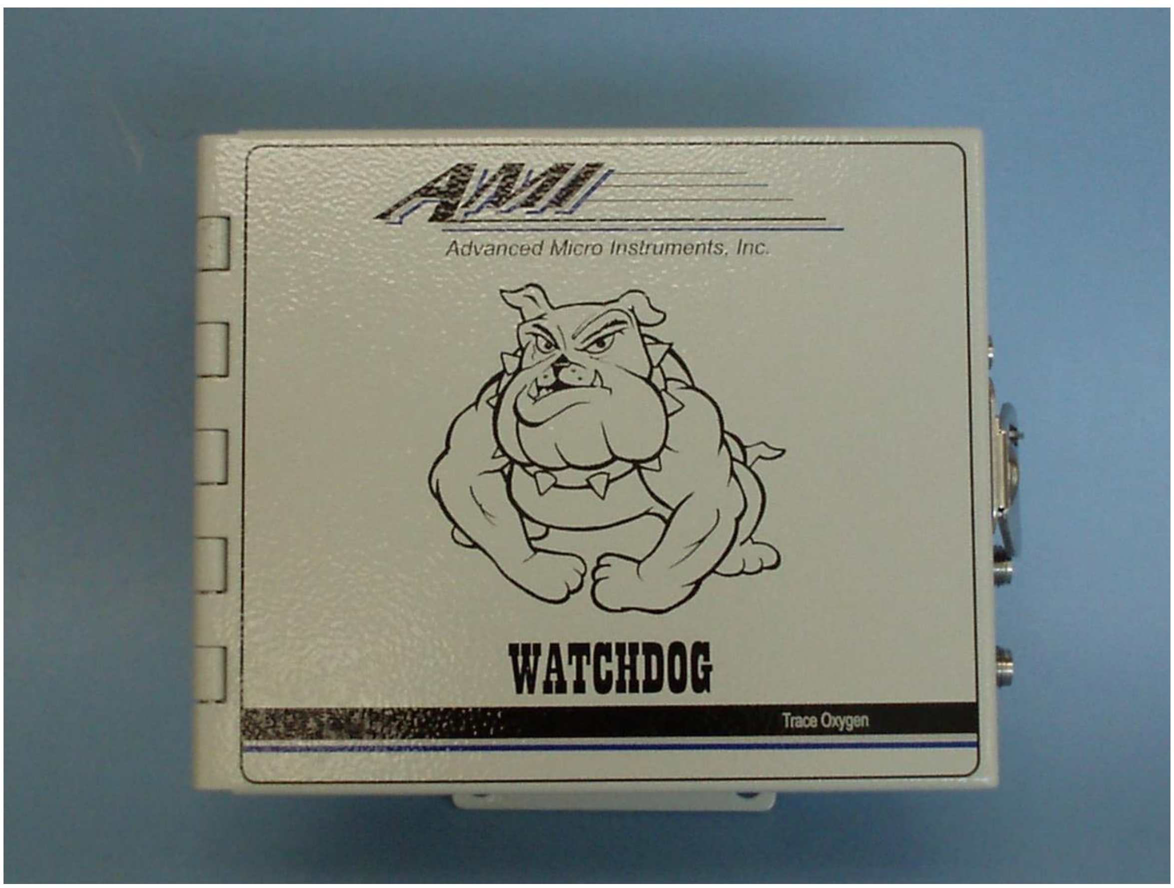
AMI

WATCHDOG (ppm)
Operator Manual



AMI, Costa Mesa, CA

Contents

Preface

Thank you!

We would like to thank you for purchasing the most advanced trace oxygen analyzer available. We have gone to great lengths to make this analyzer as simple as possible. It includes our patented cell block, (patent numbers 5,728,289 and 6,675,629), and our patented sensor. With the optional liquid rejection probe accessory and demister it provides a simple, low cost system for monitoring natural gas wells.

Please verify that the analyzer was not damaged in transit. If so please contact the shipper as well as AMI.

Trace Oxygen measurement is difficult because the air contains high levels (209,000ppm) of oxygen, and it will get into the smallest leaks. Oxygen molecules will enter through a leak, no matter the pressure or the nature of the gas in the line. This analyzer is an exceptionally sensitive leak detector – including those provided by improper installation. Make sure you read this manual carefully prior to installation.

Caution

Read and understand this manual fully before attempting to use the instrument. In particular understand the hazards associated with using flammable or poisonous gases, and associated with the contents of the sensor used.

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OM-300-030 Rev C

Watchdog Oxygen Analyzer

Introduction

The Watchdog provides the essential elements of a complete oxygen analyzer, but omits features that are duplicated by the flow computers with which it is intended to be used. If provides a complete sample control system, a means of calibration and a user-configurable analog and digital output.

This manual is divided into two major sections: a quick reference section for experienced users, and a detailed exploration of all the many features of the analyzer for all users.

This manual covers software version 5.21, issued August 2013.

Features:

- ❖ 10 user selectable output ranges to choose from. (See Note 1)
- High resolution 3 digit LCD.
- RFI protected.
- 1-5VDC and 4-20mA isolated analog output signals.
- ❖ USB virtual comport and Modbus Bidirectional RS485 communication for advanced features. (See Note 1)
- ❖ Datalog – 10 days oxygen reading recording at 1 minute per sample. (See Note 1)
- ❖ Calibration history – stores the last five calibrations with time, date, span factor and calibration gas. (See Note 1)
- ❖ Brown-out history – stores the last five brown-outs and recoveries. (See Note 1)
- ❖ Power up history – stores the last ten times the unit was powered up.(See Note 1)
- ❖ Advanced analog output calibration.
- Power requirements: 10-28VDC.
- Low minimum detection limit.
- Excellent repeatability.
- Fast upscale/downscale response times.
- Patented Cellblock Technology: Integrates all components such as: flow control valve, flow meter, 3-way calibration valve, Sample/Span/Off and compression fittings to be an integral part of the cellblock, eliminating tubing and fittings. The cell block also provides a compact size, fast response time and front panel sensor access without the need for tools.
- Area Classification: Designed to meet requirements for Class 1, Div. 2, Groups C,D application.
- Unaffected by changes in flow rate from 0.1 to 2.0 SCFH
- Wall mount or 2.0” pipe with standard pipe clamp.
- Compact size.
- 2 year warranty for analyzer, parts and labor.
- 6 month sensor warranty, life expectancy 1-2 years.

❖ **Note 1: Requires optional AMI User Interface Software**

Oxygen sensor:

AMI manufactures its own electrochemical sensor. It measures the concentration of oxygen in a gas stream, using an oxygen specific chemistry. It generates an output current in proportion to the amount of oxygen present, and has zero output in the absence of oxygen, thus avoiding any requirement to zero the analyzer. The cell is linear throughout its range. The span calibration may be performed using standard span gases or ambient air. Unlike competitive sensors, the AMI sensor is made using a high capacity metallic body that provides long life with about twice the active ingredients of conventional sensors, but with much faster come-down times – typically under twenty minutes to 10ppm from a 1 minute air exposure.

Installation and Operation

Receiving the analyzer

When you receive the instrument, check the package for evidence of damage and if any is found, contact the shipper.

Do not install the sensor until the analyzer is completely installed, the gas lines are plumbed and the electrical connections are all made; and sample or zero gas is ready to flow into it.

Installation.

This section contains important information to do with safety and installation. Please don't skip it!

Do not open the sealed metallized T-2 or T-4 oxygen sensor bag or install the sensor until the analyzer is completely installed, the gas lines are plumbed and the electrical connections are all made; and sample or zero gas is ready to flow into it. If you do you will expose the sensor to so much oxygen in the air that it will be saturated and may not come down to low levels for a very long time.

-------------------------Points to consider first! -----------------------------

Environment – what is the temperature range going to be where the analyzer will be installed? If the temperature is going to go below freezing, you need to place it in a temperature controlled meter building. If this is not possible, you should really be using a heated 2010BR. Also, make sure it won't get too hot in the summer – you may need to ventilate or even air condition a building. Use a solar panel as a sunshield if one is to be used. The standard temperature specification is 25^{o}F to 115°F.

Sample conditions – if your sample is hot and wet, you will need to keep water from condensing in the sample line or analyzer. The AMI demister brings hot and wet gases back to ambient temperature and allows the condensation and entrained liquids to fall back into the pipeline (no draining is necessary, unlike a coalescing filter which requires routine maintenance). The Liquid rejection probe stops occasional slugs of water from contaminating the analyzer, and acts as a check valve, so that if a compressor goes down drawing a vacuum on the line, air is not drawn back into the analyzer through its vent. It is available with a built-in pressure regulator for high pressure lines (up to 1200psig).

Power supply – if you are going to run the unit off solar power, using a battery, you need to size both the battery and the solar panel correctly. The analyzer draws about 30mA at 14.4 volts, but if you select the 4-20mA output option this will go up to about 60mA.

Location:

The unit is designed to be mounted on a wall or on a 2" pipe in a general purpose, Class 1 division 2 Group C,D area. It must not be mounted outdoors unless precautions are taken to avoid exposing it to temperature extremes or water ingress. **It MUST NOT be enclosed in another sealed enclosure such as a NEMA 4 box**, as this will violate its safety design. A vented box or enclosure is acceptable. Although the unit is RFI protected, do not to mount it close to sources of electrical interference such as large transformers, motor start contactors, relays etc. Also avoid subjecting it to significant vibration – don't mount it on the side of a compressor!

Give yourself enough clearance on the right side that you will not have a hard time connecting the gas lines.

Safety Considerations:

The unit is designed for installation in either a general purpose or a Class 1 Division 2 Group B,C,D area, but it is also designed so that a hazardous gas may be introduced into its main compartment. This gas may be any group B,C or D gas such as natural gas.

The enclosure is vented so that it can be considered as a Class 1 Division 2 area. It MUST NOT be mounted in a Class 1 Division 1 area, or inside another sealed box.

Flashing Display:

A flashing display indicates that the unit is measuring percent ranges. When the unit is measuring ppm levels of oxygen its display will be steady.

Short-form Installation Procedure

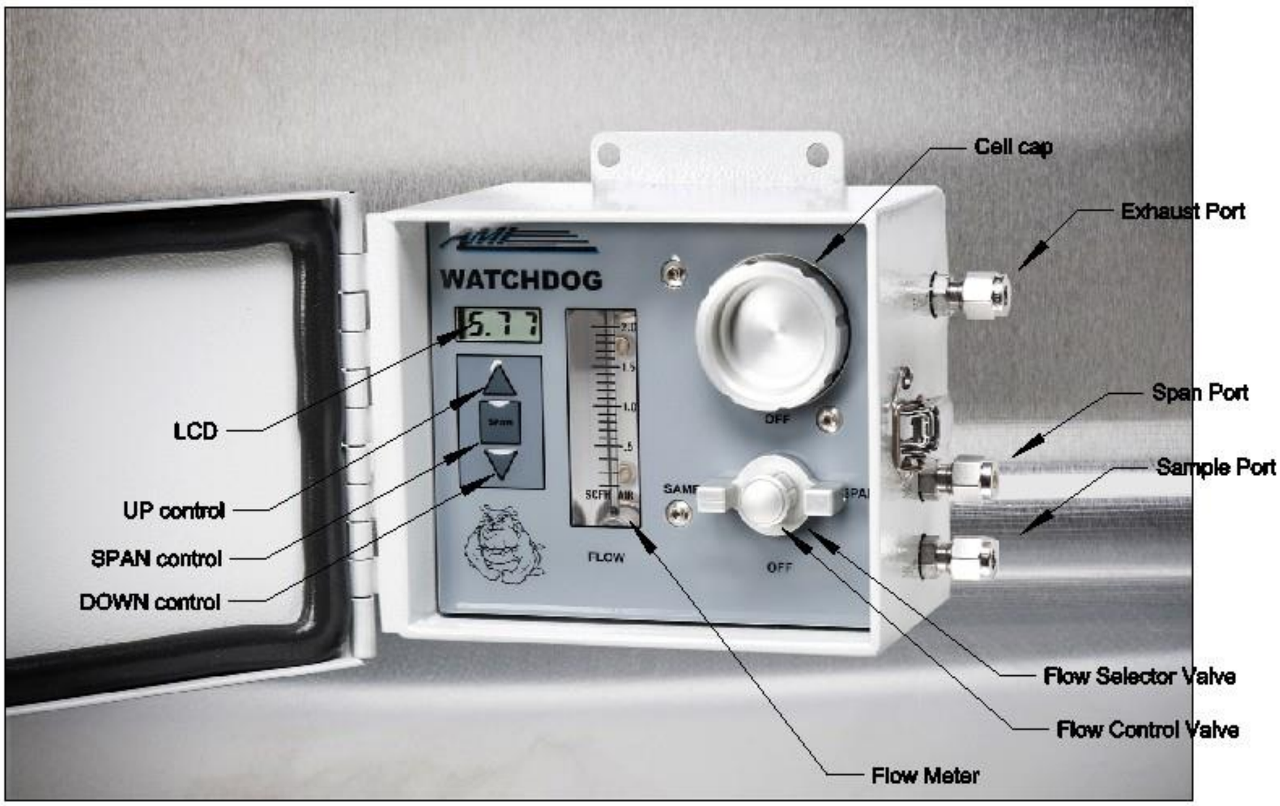

Figure 1. The Watchdog

1. Mount analyzer at a convenient eye level, not too close to the right wall.
2. Connect the analyzer ground to an 8 ft. ground rod or similar high quality ground with a minimum 16AWG wire.
3. Confirm sample pressure is less than the analyzer specification (150psig).
4. Deal with any potential condensation or liquid contamination issues.
5. Connect the sample line to the sample inlet port with ¼" ss tubing.
6. Turn the Sample/Span/Off valve to the Off position.
7. Pressurize the sample line to line pressure (between 1psig and 150psig).
8. Leak check every fitting and weld from the analyzer inlet to the sample tap.

9. Connect vent line to outside, running slightly downhill all the way.
10. Turn the Sample/Span/Off valve to the Sample position.
11. Adjust the sample flow to approximately 1 SCFH.
12. Connect power, analog output and RS485 if desired. Run the power in one conduit, and the analog output and RS485 in the other.
13. Power up analyzer.
14. Set up as desired with a laptop.
15. Turn the Sample/Span/Off valve to OFF.
16. Unscrew the cell cap, and install the oxygen sensor.
17. Remove the shorting tab on the sensor.
18. Optional: in the User Interface (version III) press the “NEW SENSOR” button, and record the sensor serial number.
19. Stabilize for 45 seconds ONLY, adjust span to 20.9%.
20. IMMEDIATELY turn the Sample/Span/Off valve to SAMPLE and flow sample gas at about 1 SCFH.
21. Replace the Cell cap and tighten it down (hand tight).
22. Remove the USB connection cable.
23. Replace the access panel on the side of the analyzer.
24. Purge with sample gas for half an hour, or until the oxygen reading has fallen to low ppm levels.
25. If desired, span with known calibration gas.

Laptop set up procedure:

1. Make sure the laptop has the FTDI driver installed.
    a. Windows 7 will probably find the driver by itself, but XP probably won’t.
    b. Run the program called CDM20824_Setup.exe which is either in the AMI CD, or can be downloaded from the FTDIchips.com site.
2. Install the AMI program if you haven’t done so already.
3. Run the program.
4. On the User Interface screen, at the top, click the “Port” button. Note the ports listed.
5. **Make sure the analyzer is powered up**, and connect the USB cable to it.
    a. **If you connect the cable without power to the analyzer, the port won’t appear.**
6. On the User Interface screen, at the top, click the “Port” button again, and you should see an additional port. Select this port.
7. Let the program figure out how to talk to the analyzer, and watch it load up all the boxes with numbers or words.

8. If you want to name the analyzer, click on the “User ID:” box. A dialog box will come up, asking for a password. Use “AMI” as the password, and then write in up to 12 characters as a name for the analyzer.
9. Set up the output range, that is the range used by the analog output to scale the output for your monitoring device. People often use 100ppm in the natural gas world.
10. Make sure the security settings are the way you want them.
11. Make sure the display shows the correct output type, 1-5V or 4-20mA.
12. Go through the analog output calibration procedure if desired.
13. If you are installing the sensor, click on the New Sensor button and write in the serial number.
14. Check the analyzer date and time is correct (we set it up for Pacific Standard time, which may not be correct for you). You can send the computer time to the analyzer by clicking the Set Analyzer Time button.
15. Clear the stored data by clicking the “Clear Data” button in the DATALOG section on the right.

Expanded Installation Procedure

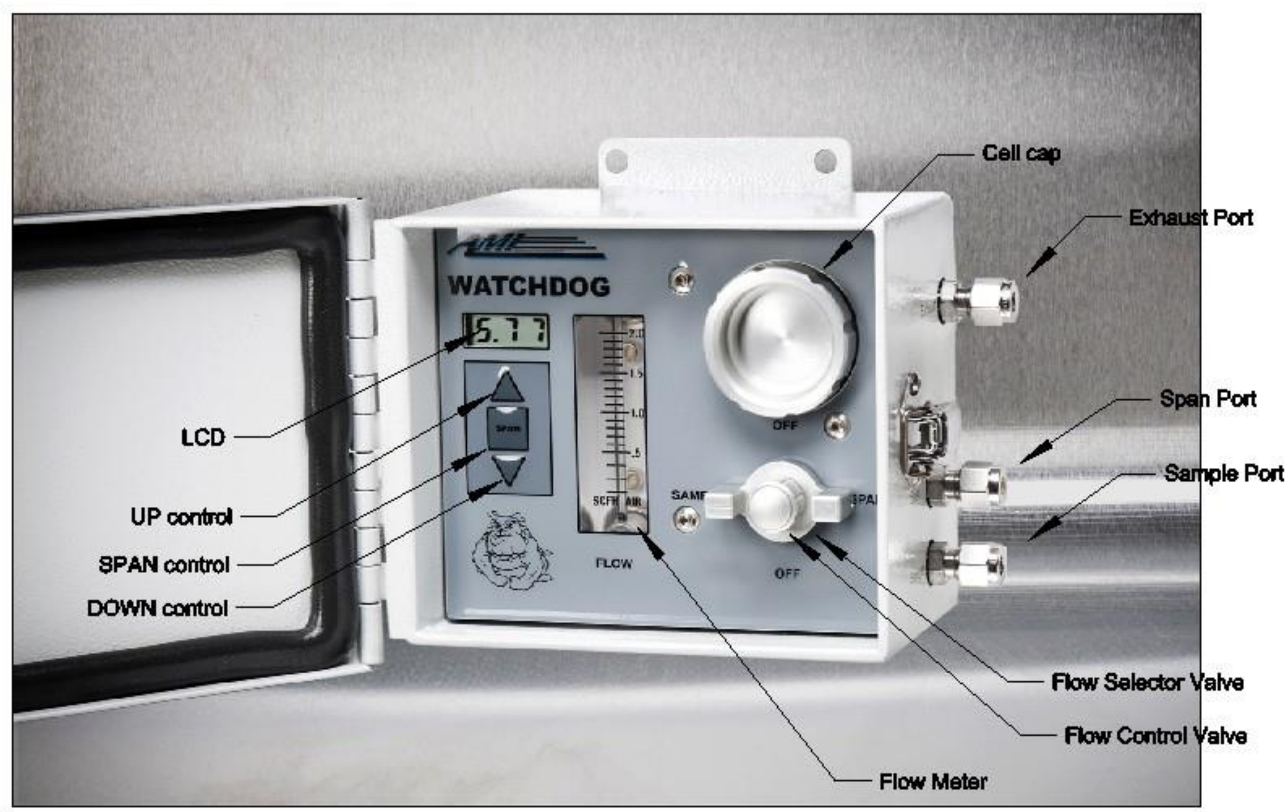

Figure 2. The Watchdog

This section follows the format of the installation procedure above but with greatly expanded explanations and coverage of detail issues.

1. **Mount analyzer in a shelter if possible, at a convenient eye level, not too close to the right wall.**

The gas connections are made on the right side of the analyzer, while the electrical connections are on the left side. Leave enough space on the right side of the analyzer for the gas connections.

The analyzer can be mounted on a wall, or on a two inch pipe.

If the analyzer is mounted outside, make sure it has some kind of sun shade. If it is DC powered with a solar panel, use the panel to give the analyzer shade.

If the analyzer is mounted in a building with other equipment, make sure it won't get too hot during the summer. The sensor will rapidly die in temperatures higher than 115°F. You may need to install ventilation or even air conditioning.

Remove the access panel on the left side of the analyzer so you can make the electrical connections.

2. **Connect the analyzer ground to an 8 ft. ground rod (or similar high quality ground) using at least 16AWG wire.**

It is **essential** for safety that the analyzer has a good ground. Normally an 8ft rod pounded into the ground will suffice, but in very dry or sandy areas something better may have to be done. Sometimes gas running in pipelines can develop serious static charges on the lines, causing the pipeline to be at a high voltage compared with the local ground. Be aware of this and make sure the pipeline is well grounded itself.

3. **Confirm sample pressure is less than the analyzer specification (150psig). If it is higher, use a suitable regulator such as the high pressure AMI Liquid Rejection Probe. Such a regulator must have a stainless steel diaphragm.**

The analyzer needs a minimum of about 1 PSIG, and a maximum of 150psig sample pressure. If the pressure is too low, the gas flow will be low and the response time long, and if the flow is very low the effect of minor leaks will become significant. If the pressure is too high the analyzer will be damaged, and you may get a hazardous situation if the sample is flammable.

The response time will depend on the length of tubing, the diameter and the flow rate of gas through it. You can roughly calculate it by assuming that the volume of tubing – the length multiplied by its internal area – has to be completely replaced by the gas flowing before you get a representative reading. If the sample pressure is high, the volume is effectively increased because more gas is packed into the tubing.

AMI can provide a version of the Liquid Rejection Probe with a built-in regulator that can handle pressures up to 1500psig.

4. **Deal with any potential condensation or liquid contamination issues.**

If the sample may contain condensable liquids, they must be prevented from entering the analyzer. Natural gas, for example, often contains water in vapor or liquid form, and other liquids such as oils, glycols or methanol. Such liquids tend to collect in dips in the sample line, and come through the line as slugs, particularly if the line is cleaned by "pigging" it (sending a cleaning device through it, preceded by a tidal wave of sludge). Compressors heat the gas and also cause liquids to condense, particularly when the gas cools off, so that even apparently dry gas going into a compressor may contain liquids coming out. AMI can provide a "Demister" and Liquid Rejection Probe" that together work to prevent problems from hot wet gases. The demister acts to coalesce droplets and cool the gas, while the Liquid Rejection Probe stops any liquids from getting to the analyzer. Any liquids fall back into the pipeline, thus minimizing maintenance issues. Also, the Liquid Rejection Probe acts to prevent the problems that arise when the source of the gas is shut off while the downstream compressor continues to run, thus pulling a vacuum on the line. Normally this would cause air to be drawn into the line through the analyzer vent, but the Liquid Rejection Probe contains a very sensitive check valve that prevents this.

5. **Connect the sample line with ¼" stainless steel tubing.**

Use stainless tubing only to connect the sample to the analyzer. Other materials are either not robust enough or in the case of plastics, allow oxygen to enter the sample via diffusion. Normally ¼" tubing is adequate unless the sample run is very long and the source pressure low – in this case you may have to use wider tubing.

You should have some kind of blocking valve on the sample port. If you use a Demister, use at least a half inch ball valve at its base.

6. **Turn the Sample/Span/Off valve to the Off position.**

The Sample/Span/Off valve is to the lower right of the grey faceplate above. This valve contains a Flow Control (metering valve) in its center. If you turn the Sample/Span/Off valve to the off position, it will stop either sample or span gas from flowing into the analyzer – but the exhaust is still connected to the atmosphere so when you have a sensor in the analyzer it is not sealed off by this valve. At this point in this procedure you shouldn't have the sensor in place yet. Don't use the metering valve to shut off the flow (as it is a fine adjustment valve)!

7. **Pressurize the sample line to line pressure (1 – 150psig).**

The exact pressure doesn't matter – we want enough so that you can easily see leaks in the following step.

8. **Leak check every fitting and weld from the analyzer inlet to the sample tap.**

Use a liquid soap solution such as "Snoop™" or similar. Don't spray it on! You are looking for little bubbles that appear after a while, indicating a leak. Even the tiniest leak will allow oxygen to enter the gas stream, no matter what the pressure inside the line is. Check absolutely every possible source including welds, valve packing, and fittings both around the tube and the nut, and anything else that might leak.

Oxygen can get into the gas stream because you are dealing with diffusion of molecules, not the flow of water. To an oxygen molecule, 3000psig of gas still has enough spaces between its molecules that it looks like zero pressure. People often don't understand this until Mother Nature teaches them about it the hard way. So at this point, be absolutely sure that you don't have any leaks.

9. **Connect the vent line to outside, running slightly downhill all the way.**

Particularly if the analyzer and gas is warmer than the environment, any water vapor in the gas will tend to condense in the vent line. If the line runs uphill, or has a low point, water will collect and potentially freeze, stopping the flow. If the sample gas is flammable, the vent must go to a safe area.

Also take precautions that insects don't make nests in the exhaust line. You may need some sort of a grill over it.

10. **Adjust the sample flow to approximately 1 SCFH with the Flow control valve located in the middle of the Sample/Span/Off valve.**

The Flow Control Valve is the metering valve in the middle of the Sample/Span/Off valve. It is a sensitive needle valve – so don't try to use it to shut off the flow. Turn the main valve to the OFF position for this.

The exact flow rate is not important – 1 SCFH is half way up the flow meter, so is easy to see. You want the flow between about 0.5 SCFH and 2 SCFH at the maximum. Lower flows will result in longer response times, and possibly higher oxygen readings as minor leaks aren't diluted as much by the flow. Higher flow rates will tend to increase the pressure on the sensor which will increase the oxygen reading.

11. **Leave the Sample/Span/Off valve on the analyzer pointing to SAMPLE and allow the sample gas to purge the unit while you wire it up.**

You want to get rid of all the oxygen trapped in the tubing, fittings and dead areas in the cell block. Also, at the oxygen levels we are normally measuring we essentially have to flood the whole sample system with enough gas to dilute the oxygen originally in the tubing enough to become insignificant. You don't push out one gas with another – the new gas simply dilutes the old gas in the system. Again, this is not intuitively obvious.

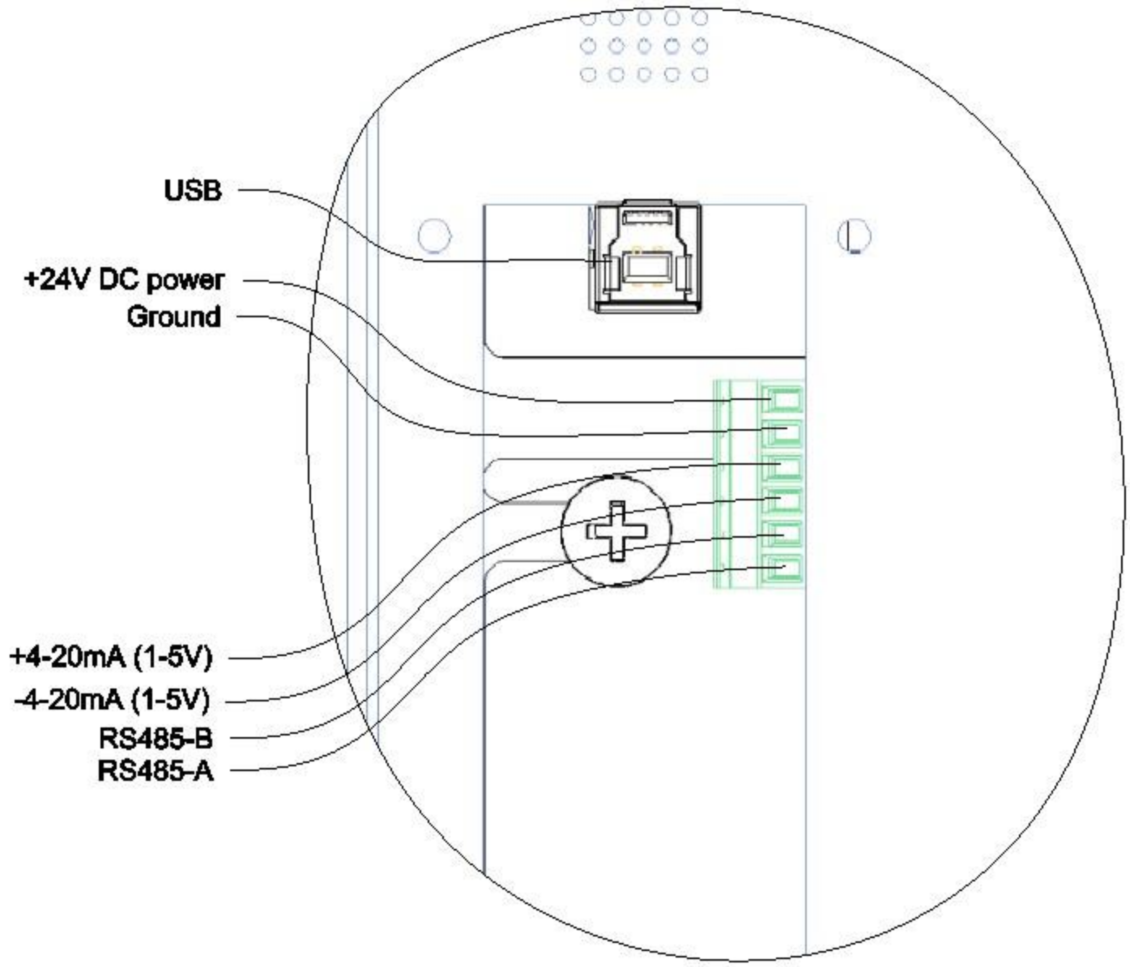

Figure 3. Electrical connections

12. **Connect power, analog output and RS485 if desired. Run the power in one conduit, and the analog output and RS485 in another. You can use flexible conduit for Class 1 Div. 2 areas. See the NEC.**

All the electrical connections are located on a single Phoenix pluggable connector behind a panel on the left side of the analyzer. Make sure the wires are connected per the markings – Positive to +ve, return to the ground symbol. This terminal should also be used if required for any shield connections for the output or RS485 connections. The output connections are made on positions 3 and 4, and the RS485 connections on 5 and 6.

The analog output – which may be either 1-5V or 4-20mA – is connected to the "+" and "-" symbols (3 and 4). This signal is isolated from ground. If the device to which you are connecting is also isolated from ground, make sure you ground the "-" connection at the analyzer. The terminal marked by the ground symbol may be used for this purpose, in which case the output is no longer isolated. DO NOT GROUND

BOTH ENDS! If you do so, you will generate a ground loop which will seriously upset the readings. Normally you would use the ground terminal for a shield. You can select which output is in use. The voltage output is lower power, but more prone to interference. If you decide to change it, you will probably have to perform an output calibration, described later in this manual.

The two terminals marked A and B are for the RS-485 ModBus connection. This is not isolated from ground.

Run the power through one conduit, and the analog output and RS485 lines through the other.

Make sure you are following the NEC (National Electrical Code) when you wire it up. Also make sure you have a way of removing power from the analyzer nearby, per the code.

13. **Power up analyzer.**

When you do so, the LCD should light up.

14. **Turn the Sample/Span/Off valve to OFF.**
15. **Unscrew the cell cap, and install the oxygen sensor.**

Unscrew the cap first. Open the sensor bag, remove the sensor by holding the little handle and immediately put it into the cell compartment, gold side up, and with the little metal tag on the side facing you. When it is in place, hold the sensor in place and pull out the tag. Do it in this order so that the sensor is always operating, eating up oxygen that gets in through its membrane. The length of time you take over this is critical in determining how long the sensor takes to get down to a low range.

16. **Optional: in the User Interface (version III) press the "NEW SENSOR" button, and record the sensor serial number.**

You might just want to write it down. Note that you can read the serial number while the sensor is in place in its cell block pocket – don't leave the sensor out while you write it down.

17. **Stabilize for 45 seconds ONLY, adjust span to 20.9%.**

It will take the sensor about 20 seconds to come to a reasonably stable reading, but give it 45 seconds to be sure. Don't go over this time, even if the reading is still moving. The sensor is probably changing temperature a bit which affects its reading until it has equilibrated with the analyzer. You aren't concerned with the utmost precision at this point, just a close-enough value. If you leave the sensor in air too long, it will take much longer to come down to low oxygen levels than you expect.

18. **IMMEDIATELY turn the Sample/Span/Off valve to SAMPLE.**

Do this before you screw on the cell cap, because you will get rid of most of the air in the cell pocket immediately, helping the sensor come down quickly.

19. **Purge with sample gas for half an hour, or until the oxygen reading has fallen to low ppm levels**

it should drop to less than 10ppm in less than 20 minutes, if it has been installed properly, the temperature is above 50^{o}F, and always assuming your sample has less than 10ppm of oxygen in it. (Cold temperatures cause the sensor to respond more slowly).

You may be required to perform a low level span – this means spanning the analyzer with a suitable span gas whose value is close to where the analyzer will be operating. If so, it is essential that the analyzer gets down to a lower value than the span gas value, or it will take forever to exponentially work its way down to the span gas reading.

Often this operation causes problems. For example, the span gas may be contaminated, or the regulator hasn't been properly bled. A good first step is to simply run the span gas through the analyzer and see what it reads. If it is close to the correct value, you can go ahead and span it. If it isn't, you MUST trouble shoot why not before you believe the span gas! The calibration you just did on air is going to be accurate to within about 2% of reading, probably, which is closer than many span gases!

20. If desired, span with known calibration gas.

a) Connect a regulator (with Stainless Steel diaphragm ONLY) to span gas tank.

A regulator with any other kind of diaphragm will allow oxygen to diffuse into the gas, contaminating it.

b) Bleed high pressure side of the regulator 7 times.

This effectively removes trapped oxygen from the air in the primary side of the regulator. If you just try to purge it by flowing gas through it, it will take a very long time to get rid of all the air and you may contaminate the gas in the bottle. Bleeding the regulator can save days of time.

c) Bleed low pressure side of the regulator 7 times.

Removes the air from the secondary side. Bleeding the regulator can take days off the stabilization time.

d) Shut off the regulator outlet valve and leak check all fittings, gauges and packing glands with Snoop™ or equivalent.

Again, flow the liquid on, don't spray it on. Make sure you check the regulator and tank valve as well.

e) Flow calibration gas preferably through a length of AMI supplied tubing WHILE you are connecting the tubing to the span gas fitting. Allow the gas to purge around the fitting for about 20 seconds before you tighten it.

It is preferable to use the AMI special flexible non-diffusive tubing with its O-ring sealed fittings so that you don't destroy the span inlet fitting on the analyzer. This can be purchased from AMI as an option. Compression fittings can only take a few openings and closings before they cease to seal well enough for a trace oxygen analyzer. Flow the gas through the tubing while you attach it to the span fitting: screw it on by one thread allowing the gas to escape around it, and after about 20 seconds tighten it up. This displaces the air from the fitting, meaning that you don't inject a slug of air onto the sensor and delay it coming to stability.

f) Tighten fitting on the span gas inlet.

Use Snoop™ or equivalent to leak check it.

g) **Turn the analyzer Sample/Span/Off valve to the SPAN position.**

You will probably see the reading shoot up for a moment as the air in the span gas port is pushed past the sensor, then the reading will start to stabilize.

h) **Allow to stabilize for 2-5 minutes.**

This will allow any residual air to be flushed out and the sensor to come to equilibrium.

i) **Verify that the analyzer reads within about 15% of the span gas value.**

If it doesn't, something is wrong. If the sensor reads very low, check it on air, and if that reading is also very low, replace the sensor (you shouldn't have to do this with a new sensor!) If the reading is too high, it is possible that your span gas is contaminated, or you have a leak, or you have made some kind of error. One thing to note is that if the analyzer temperature is very different from the sensor temperature when you put it in, the reading will be quite wrong until the sensor has had a chance to equilibrate. Increase the flow rate by doubling it, and see if the reading decreases after a few seconds. If the reading goes down with higher flow, you certainly do have a leak. You can also time how long it takes, which will give you an indication of where the leak is. The longer it takes for the flow change to affect the leak, the further from the analyzer is the leak source. Fix it by using Snoop and try again.

j) **If so, adjust the analyzer span until it reads the span gas value.**

Press the SPAN button. The SPAN flag should appear on the LCD. Press the UP or DOWN arrow buttons until the reading is correct

Note: Note that when holding the arrow button down, it may take up to 15 seconds for the display to reflect a value change.

k) **Let it go back to normal operation then press the UP arrow and note the number displayed (the "Calibration factor").**

You can use this to get an idea of the remaining cell life in the future. The analyzer also stores the calibration values in memory so you can view the history later. When the sensor is new it will have a Calibration factor (also called Span factor) of about 450. As it gets used up, this number will have to increase when you span the analyzer until it gets up to around 950 or so (the Calibration factor doesn't increase by itself, it only does so when you span the analyzer). You will probably see the span factor remain fairly constant, then suddenly change. When it does so it means that you will need a new sensor soon. The sensor behaves rather like a NiCd battery – it is stable until suddenly it starts to fail.

l) **Rotate the valve back to the Sample position.**

The analyzer is now set up and calibrated. It is normally good practice to give it a day or two and recheck the calibration.

Analyzer Description

Basic description:

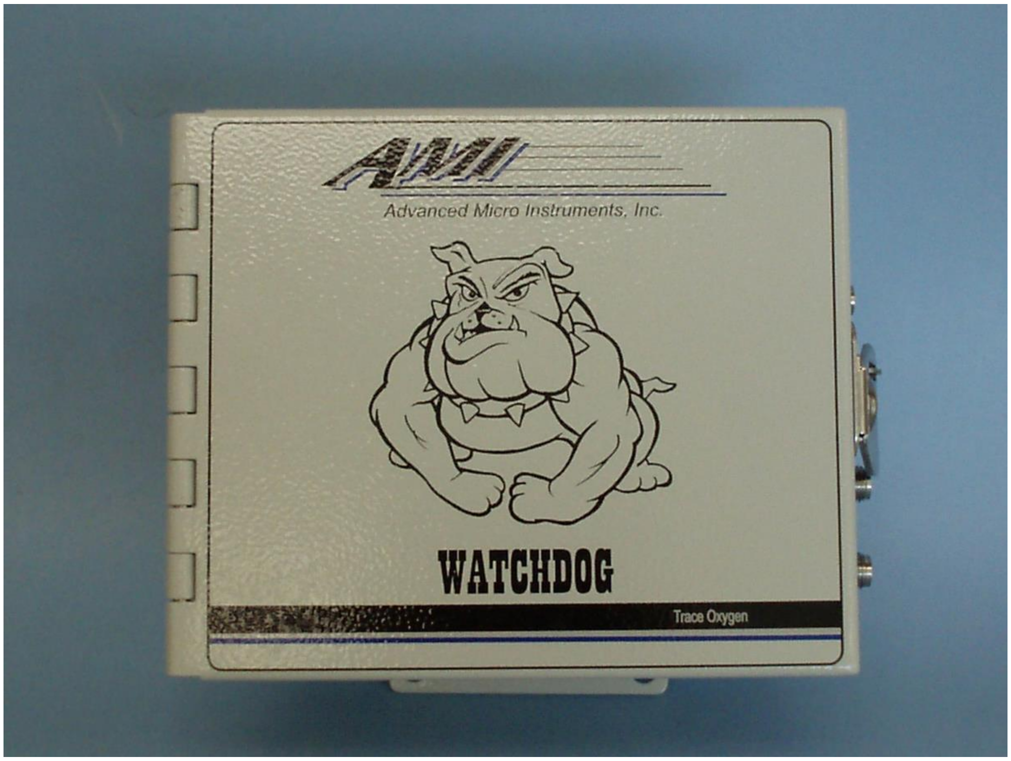

Figure 4. Analyzer (closed)

The Watchdog measures oxygen in a flammable (or inert) gas stream down to under 0.1ppm. It is intended for use in non-hazardous or Class 1 Division 2 areas when properly installed.

All components are contained in one compact enclosure. The sample system components are all integrated into a “Cell Block” located behind the front panel on the right, and the electronics are contained on a single circuit board also located behind the front panel, on the left. All the electrical connections are available under a panel on the left side of the instrument.

The actual oxygen measurement is performed by an oxygen sensor located behind the cell cap on the right.

When the unit is reading oxygen in ppm levels, the LCD will be steadily on. It flashes for percent levels.

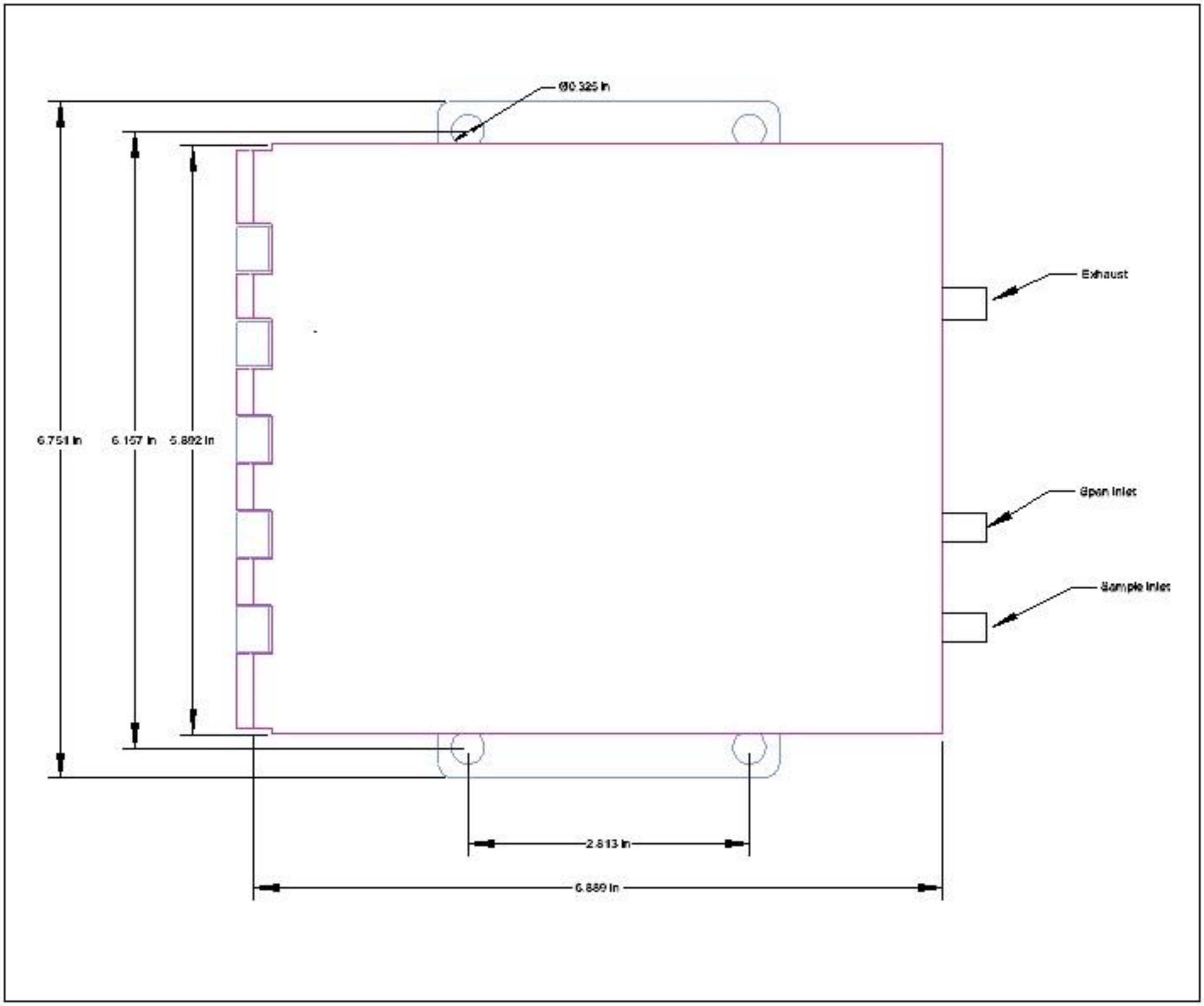

Figure 5. Outline Drawing

General Information

Basic knowledge about oxygen measurement

Oxygen is a chemically active gas that is present in the atmosphere at 20.9% concentration. It is essential for animals including humans as it is the active part of air used in breathing. However since it is so active, small amounts of it can cause havoc in situations which are not supposed to have it. In natural gas, for example, small amounts of oxygen cause the other chemicals present in the gas to combine to form acids that destroy piping and chemical systems; in semiconductor manufacturing it changes expensive integrated circuits into sand, or at least stops them from working properly. In chemical operations it can prevent polymerization or otherwise degrade the performance of the process.

Gases obey the gas laws formulated in the end of the 18^{th} century and still not well understood by many people. A gas consists of a very large number of independent molecules that fly around in otherwise empty space. Gases don't interact with each other (normally), so that you can treat the behavior of each gas as if no other gases were present. Thus you can consider that air consists of nitrogen at about 11psia, and oxygen at about 3 psia, and various other gases at lower pressures. "psia" stands for Pounds per Square Inch Absolute, i.e. it is the pressure above zero, not the pressure above atmospheric pressure as it would be if we were to use the units psig (Pounds per Square Inch Gauge). Since we are only worried about oxygen, mostly because nitrogen does not matter normally to the chemistry we are worried about, we can think of air as being pure oxygen at 3 psia pressure. In a pure gas stream, or in natural gas, there is zero oxygen ideally, i.e. it is at zero pressure. This means that if there is a leak in the piping, there exists a pressure difference of 3psia forcing oxygen into the leak. The oxygen doesn't care about or see the other gas in the pipe, it thinks of the pipe as being a vacuum. People normally don't intuitively understand this, they think of the gas as being rather like a pipe full of oil in the sea, where if there's a leak oil will come out but it will keep any water out of the pipe. However that's not the way it is with gases because the space between the molecules is very much larger for a gas than it is for a liquid, so one gas does not push another out of the way.

The bottom line is that oxygen from the air will force its way into a pure gas system regardless of the pressure in the system. It will do this through little holes, or through permeable materials such as all plastics or rubbers, to greater or lesser extent. Nitrogen will do this as well, but since nitrogen is comparatively inert normally its presence doesn't matter. Also it is much harder to measure, while oxygen is comparatively easy, hence oxygen is normally used to verify the integrity of the system.

As a consequence of this, the integrity of the oxygen analyzer sample system is critical. AMI analyzers are designed around a patented "Cell block" that integrates all of the sample handling elements into one solid chunk of metal, resulting in much fewer leak sources and therefore much greater reliability, as well as lower cost.

It is just as important that the analyzer's sample system – the components used to control the gas flow – are perfect as the measurement methodology itself. No matter how good the analyzer is, if you don't connect the plumbing correctly you won't get good results.

Sample tubing and components

Oxygen diffuses through plastics, to a greater or lesser extent. Standard blue poly tubing will diffuse about 1ppm per foot into 1SCFH at 70°F. Silicone tubing is very much worse. In general, use stainless steel tubing, or at least copper tubing, not plastic. Use high quality compression fittings such as “Swagelock™” or “Gyrolock™” and high quality stainless steel filters, valves or regulators if necessary. Make sure that they are assembled correctly and perform a thorough leak test on the sample system before use.

The analyzer expects to see sample pressures between about 1 psig and 150psig. Higher pressures will overwhelm the input valve and make it hard to control the flow. If your pressure is higher than this use a regulator with a stainless steel diaphragm to bring the pressure down appropriately. The analyzer is not very much affected by changes in flow rate and the internal flow meter is adequate for setting the flow. Don’t use a high precision external flowmeter in front of the analyzer because oxygen will diffuse in through its O rings.

The span gas pressure should also be held below 100psig, and normally would be controlled to 10psig. AMI recommends that you use a length of their flexible tubing with O ring seals on its fittings so that you don’t damage the analyzer fittings by making and breaking them too often.

Leaks

If you suspect a leak due to high oxygen readings, change the flow rate and see how long it takes for the oxygen reading to change. A higher flow rate will dilute the effects of a leak so that the reading will drop as you increase the flow (this is a very good way of making sure that you do not in fact have a leak, by the way). Turn the flow up from 1 SCFH to 2 SCFH using the front panel valve and see how long it is before the reading changes. If it does so immediately, the leak is close to the analyzer. If it takes longer, the leak is further away.

Exhaust

The exhaust port of the analyzer should be given at least a foot of tubing, but it should not be allowed to become pressurized, or the readings will be affected. It should be vented outdoors or brought into a scavenging system. If the latter, have the scavenging system suck in room air around the exhaust line so that the pressure at the exhaust is atmospheric. A typical way of doing this is to have the scavenging system suck on a 1” pipe, and have the ¼” exhaust line from the analyzer extend six inches or so into the end of the pipe. If it is likely that a loss of flow could happen, use a “Back Diffusion Assembly” to prevent air from getting back into the analyzer if this should happen.

Calibrating the analyzer

The oxygen sensor gradually gets used up over its life, and as it does so its sensitivity slowly drops until it is at the end of its life, when the sensitivity drops much faster. Therefore you have to calibrate the sensor every so often to make sure that your readings are correct.

There are two ways of doing this. You can use a span gas, a mixed gas containing a certain level of oxygen in a background gas that ideally matches your sample, but is normally nitrogen, or you can use air. The advantage of using air is that its value really is 20.9% and it doesn't change; the disadvantage is that it means that the sensor is exposed to air and so it will take a while for the reading to come down again afterwards. Typically, at room temperature, an AMI analyzer will take about twenty minutes or less to come down to below 10ppm after a one minute exposure to air.

The advantage of using a span gas is that you can calibrate it to a value close to the range of interest – often people use 80ppm oxygen in nitrogen as the span gas. You may have political reasons for having to do this. The sensor recovers from this level of oxygen immediately so there is no down time before the analyzer is working properly again. The disadvantage is that span gases sometimes are incorrectly made, and they can be contaminated by improper handling.

Calibrating with a span gas

First, put a suitable regulator on the span gas tank, and "bleed" it as described below. This step is essential, since otherwise the air in the regulator will contaminate the gas in the tank. Connect the regulator to the analyzer with a flexible line such as that provided by AMI, and leak check the connection with "Snoop™" or similar leak detection fluid. Purge the line for several minutes with a small flow of gas prior to doing this, and leave the gas flowing while you make the connection to the analyzer. This prevents a slug of air from giving you excessively high readings when you start spanning the analyzer.

Make sure the analyzer is seeing a low oxygen level gas – you want the analyzer to go UP to the span gas, not down to it, particularly not from air. Otherwise it will take a very long time to get a good calibration.

When all is assembled, turn the flow selector valve on the front of the analyzer to the SPAN position. Span gas is now flowing into the analyzer, and you should see the reading move to the span gas value. Assuming it stabilizes somewhere reasonably close, press the SPAN button and then the UP or DOWN button until the reading on the LCD shows what the span gas bottle says the value should be. Let go of the buttons, and after a second or two the analyzer will store its calibration value. Return the flow selector valve to the SAMPLE position.

Note: When holding the arrow button down, it may take up to 15 seconds for the display to reflect a value change.

Calibrating with air

You can either connect a compressed air line – from the plant air, not a bottle of compressed air – to the span port or you can leave the span port open. If you use compressed air, go through the same procedure as above, only adjust the oxygen reading to 20.9%. Bottles of compressed air are frequently actually a nitrogen/oxygen mixture and may not contain exactly 20.9% oxygen.

If you do not have compressed air, turn the flow selector valve to OFF, and unscrew the cell cap on the front of the analyzer. Blow some air under the sensor by waving a hat or some such at it. Adjust the reading as before to 20.9% and then turn the flow selector valve back to SAMPLE. Then screw the cell cap back on the analyzer.

In either case, make sure you don't take more than a minute to do this. The reading may not stabilize exactly at 20.9%, but don't worry about that – any slight error will be inconsequential at the operating levels.

Let the analyzer come down to a low reading on the sample gas.

Span problems

Sometimes you will run into problems. If the sensor is old, it may not be able to come up to the span gas level. If so, you need a new sensor. Sometimes sensor will calibrate on span gas but will fail on air. This also indicates an old sensor. You can see the sensor state by pressing the UP button when the sensor is showing the oxygen level – it displays the "Span factor", a number between about 450 and 1000. As the sensor gets old each calibration will increase this number and when it gets up to about 850 it is time to replace the sensor.

Sometimes the sensor won't calibrate on span gas properly, but since it is a new sensor you figure something must be wrong. If something like this is happening, perform an air calibration and allow the sensor to come back down to a low reading on the sample. Then perform a span gas calibration only don't adjust the span factor with the UP or DOWN buttons, and see what the analyzer says the gas contains. If the gas value isn't what you think it should be, it is the gas that is wrong, not the analyzer, because that air calibration is in fact very valid. You will have to trouble shoot whatever has happened with your gas.

Gas Connections:

Do not install the sensor until the gas lines have been connected and the electrical connections made.

Connect the sample gas line to the sample inlet fitting on the right side of the analyzer; the span gas (if any) to the span gas inlet, and the exhaust line to a suitable vent. All fittings are ¼" compression fittings.

Sample gas:

The sample gas pressure must be below 150psig. The connection is a ¼" compression fitting. We recommend that you use a Liquid Rejection Probe together with a demister on the sample line if there is any possibility of water or entrained liquids in the sample. **Don't allow liquids to enter the analyzer!**

Span gas:

The span gas should be set to about 10 psig. Do not leave the gas cylinder on when you are not spanning the analyzer. Any leak will contaminate the span gas bottle, or alternatively drain it. Turn the bottle off with the cylinder valve.

Exhaust:

The exhaust must be arranged in such a way that it will not plug under any circumstances. A typical means of ensuring this is to run the exhaust line next to the (warm) gas lines so that it always remains above freezing. The exhaust is typically a flammable gas, so it must be vented in a safe area. The exhaust line should run downhill, so that pockets of condensate do not collect at the low point.   A "Back diffusion assembly" may be used to prevent diffusion of air back into the sensor should flow be lost.

Power connections:

The analyzer is designed to operate off a nominal 12 -24V DC supply such as a lead-acid battery. The Absolute Maximum Voltage is 28VDC, and the minimum is 10V.   If the power supply exceeds 28V, the unit will shut down until the excess voltage goes away, unless the voltage exceeds 240V, in which case the unit will be damaged. At some point below 7V, the unit will shut down with no damage.

The unit is supplied with a six-position connector. The connections are as shown in the drawing below.

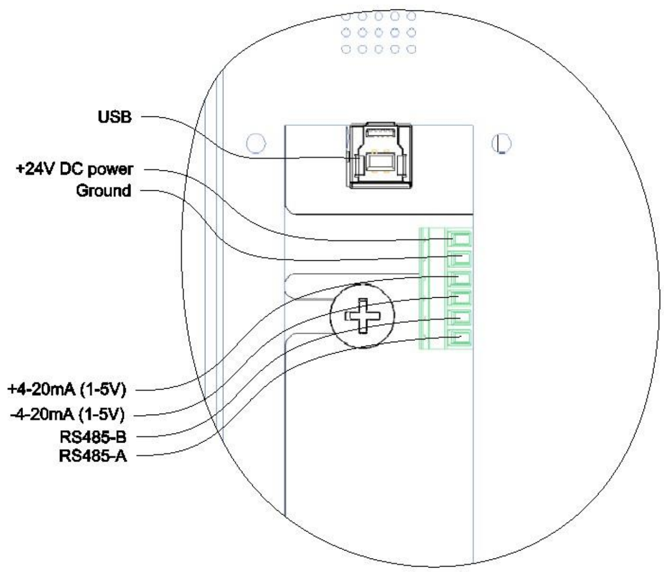

Figure 6 Electrical connections, viewed from the analyzer side

The ground stud on the bottom of the box MUST be made to a good earth, with a resistance to ground of less than 1 Ohm.

Output connections:

This unit is provided with a single output, either 4-20mA or 1-5V as ordered. It is possible to change this and also to calibrate the output to the monitoring device using the AMI User Interface. See the AMI User Interface manual for details on this.

Sample Handling:

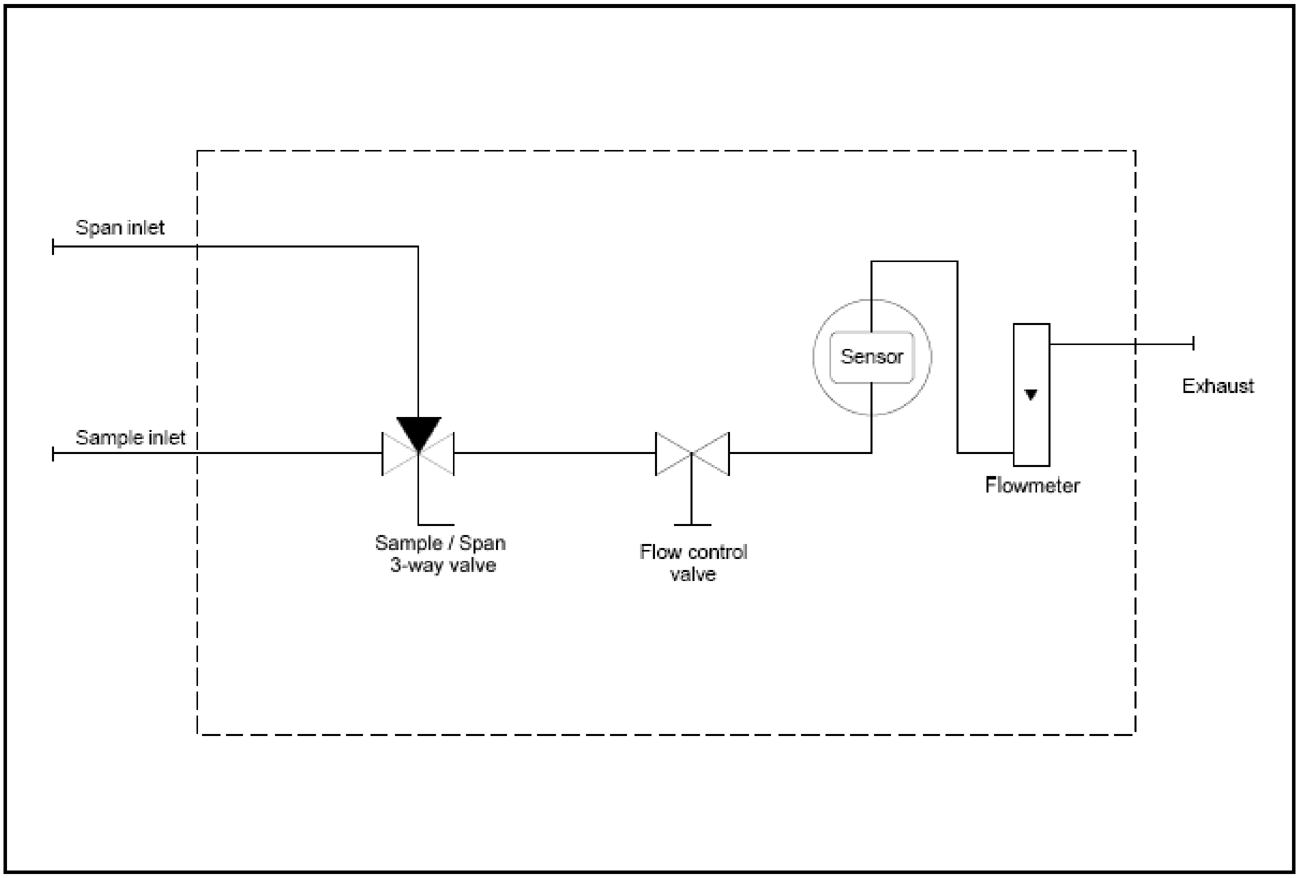

Figure 7 Flow Schematic

The sample is brought into the sample/span selection valve which contains an integral flow control needle valve.

The sample (or span gas) passes through the sensor compartment and exhausts through the flow meter.

The exhaust must be vented in such a fashion that the line will not freeze up, but on the other hand the flammable gas leaving the exhaust line will not pose a hazard. If there is a possibility of losing flow, a back-diffusion assembly should be used to safeguard the sensor against high oxygen levels from air saturating it.

NOTE: Never allow the vent to become restricted, thus back-pressuring the sensor. Doing so will cause inaccurate readings and may damage the sensor

Gas pressures:

The gas pressure must be at least 0.5psig, and less than 150 psig. If the sample gas is at a higher pressure than that, a regulator should be used to reduce it to about 20 psig. This will allow the needle valve to give a good degree of control .

Sensor Installation:

The sensor is supplied sealed in a barrier bag. When you are ready to place it in the analyzer, open the bag and rapidly place the sensor in its compartment, sensing side down. If desired, rapidly calibrate it on air and immediately flow sample gas; if you want to perform a calibration using a certified gas standard, we recommend using a value of between 20 and 100 ppm for best accuracy and minimum chance of error. In this case, flow zero or sample gas over the sensor for about two hours until it has come done to a level below 2ppm, and then perform a span calibration using the span gas. See "Calibration" below for details.

If the reading fails to drop below 2ppm, introduce a certified zero gas, or ultra-pure nitrogen and confirm that the analyzer does indeed come down to below 2ppm. NOTE: THE REGULATOR MUST BE THOROUGHLY BLED! See "Bleeding a Regulator" below for details.

Hydrogen Sulfide:

The standard AMI T-2 sensor can withstand up to 10ppm of hydrogen sulfide for its expected life, while the optional T-4 sensor can withstand up to 500ppm of hydrogen sulfide for its expected life.

Communications

The Watchdog supports both a USB link to a local PC, and RS485 over a network. Only one of these can be active at a time, and the unit automatically turns off the RS485 if it detects a computer plugged into the USB connection. Therefore the PC connection over the USB has priority.

The USB connection supports the proprietary AMI protocol, and AMI provides a program on a CD that interfaces with the analyzer. Alternatively it is possible for someone familiar with communications on a PC to directly use the protocol. See the AMI communications manual for details.

The RS485 port supports ModBus RTU at 9600 baud.

These are described in the various communications manuals available on the web site.

Advanced Features

The analyzer has many advanced features that are only accessible through the AMI User Interface. For details see the User Interface manual. The features include a data log, a calibration log, power failure log, and many other detailed bits of data. Most of these features are also available over the ModBus link.

Maintenance and troubleshooting

Maintenance:

The Watchdog is virtually maintenance free other than for periodic calibration and occasional sensor replacement.

Periodic Calibration:

The analyzer should be calibrated about once every month to obtain the best accuracy. The sensor typically declines in sensitivity by about 1% per month, so a monthly calibration is usually satisfactory. Use in a particularly aggressive environment may degrade the sensor faster: in this case calibrate more often.

You can see the "Span factor", the internal calibration coefficient for the sensor, by pressing the UP arrow. As the sensor ages, during each calibration this factor will increase. It will start around 450, and by the time it reaches 1000 the sensor is dead. By 850 the sensor is getting pretty dubious, and it would be a good idea to replace it at that point.

Sensor Replacement:

This should be done periodically, rather than as a response to a dead sensor. See the chart below for recommended sensor replacement.

Sensor	Part number	Description	Warrantied life
T2	4SEN09-1	Trace oxygen - CO_2 background, up to 10ppm H_2S	6 months
T4	4SEN18	Trace oxygen - CO_2 background, up to 500ppm H_2S	6 months

Table 1. AMI trace sensor types

Shorting clip:

The sensor is shipped with a little slip of metal plugged into a tiny socket as a shorting clip. Place the sensor in the cell block, and then pull out the shorting clip. This minimizes its exposure to air, and helps it to come down faster.

Sensor replacement cautions:

CAUTION: The sensor contains a caustic or acid liquid. If there is any sign of a liquid in the cell compartment, do not allow it to come into contact with your skin. If it does, immediately flush the affected area with water for a period of at least 15 minutes. Refer to the Material Safety Data Sheet provided

Dispose of leaking or used sensors in accordance with local regulations. Sensors usually contain lead which is toxic, and should generally not be thrown into ordinary trash. Refer to the MSDS to learn about potential hazards and corrective actions in case of any accident.

Figure 8. Inserting sensor in cell block

Sensor replacement procedure:

1. Turn off the sample gas flow using the flow selection valve on the front panel.
2. Unscrew the cell cap.
3. Remove the old sensor.
4. Open the bag containing the new sensor.
5. Push the new sensor into the block using its handle as shown above.
6. Holding the sensor in place, pull out the stainless steel tag.
7. Allow the reading to stabilize for 45 seconds, then span the reading to 20.9%
8. Turn the valve back to sample.
9. Replace the cell cap.
10. Screw it down tightly but only hand-tight.
11. Dispose of the old sensor in an environmentally appropriate way. It is similar to a lead-acid battery in terms of environmental hazard.

Bleeding a regulator

A newly installed regulator on a bottle of span gas is of course filled with air, at 210,000 ppm of Oxygen. Until this air is removed, the apparent oxygen concentration in the span gas will be much higher than it should be. While simply flowing the span gas could take days to purge the trapped oxygen, it is much quicker and more reliable to “Bleed” the regulator first.

1. Install the regulator on the span gas bottle, but do not open the bottle valve yet.
2. If the regulator has a shut off valve on its output side, close it.
3. Briefly open the bottle valve (to pressurize both side of the regulator), and close it again.
4. Use “Snoop™” or equivalent to completely leak-check the regulator, gauges, fittings and bottle valve.
5. Loosen the nut connecting the regulator to the bottle and allow the high pressure gauge to bleed off to zero, and then immediately tighten it again.
6. Open the regulator to its full pressure.
7. Repeat steps 3 and 5 seven to ten times.
8. Set the regulator to its correct output pressure (typically 10 psig).
9. Close the bottle valve.
10. Open the output shut off valve located on the low pressure side of the regulator until both gauges drop to zero.
11. Close the shut off valve.
12. Open the bottle valve.
13. Repeat steps 9, 10 and 11 seven to ten times.
14. Now open the bottle valve, and the shut off valve, and allow gas to flow through the tubing to the analyzer for two minutes before tightening the compression fitting on the analyzer..

Troubleshooting

Basics of trace oxygen troubleshooting

Most problems are due to either leaks, or a used-up sensor.
Oxygen is of course present in air at about 3psi partial pressure, and the rate at which it diffuses into a gas line is only dependent on the difference in the partial pressure between the gas in the line, and in air. Since there is normally (hopefully) no oxygen in the pipe, that full partial pressure differential drives oxygen into any leak, no matter what the partial pressure of any other gas may be. Any leak therefore will increase the oxygen in the sample. This is also true for span gas – a leak at the regulator on a span gas tank can allow oxygen to flow into the tank, changing its oxygen level and making any spans performed with that gas incorrect.
Typical life expectancy of a sensor is somewhere between one and two years, depending on oxygen levels. If they are exposed to too much oxygen, they will get used up, but also they may get saturated by being exposed to too much oxygen and not be able to come down to low levels for a long time, even a matter of days. We strongly suggest that you keep its air exposure to a maximum of one minute for best downscale response time, and always keep it shorted when it is not in the analyzer. Leave its shorting clip in until you have put it into the cell block, and only then pull the shorting tab out of the sensor.
If the sensor is deeply frozen (below about 25^{o}F), or cooked (above 115°F) the membrane can be damaged and if so, it will no longer read correctly. This may or may not happen. Also, the sensor can be poisoned by excessive levels of H_2S or other poisonous gases. Any of these things will cause the sensor to read too low.

Reading too high is normally caused by too much oxygen – either in real time due to a leak, or else because the sensor has been saturated with air. You may be able to detect this latter by looking at the data log. If you suspect a leak, due to excessive oxygen readings, you can often get an idea of where it is by changing the sample flow rate. If the oxygen reading decreases as you increase the flow rate, that is a sure sign of a leak since the intake of oxygen is pretty constant, but the dilution of that oxygen by the sample is of course greater with a higher flow rate. If you time how long it takes for the reading to decrease, the distance to the leak source is more or less proportional to the time it takes to fall. If it goes down immediately, the source is very close to the sensor – possibly the cell cap is loose, or perhaps an O ring in the analyzer valve is damaged. If it takes a while for the reading to change, the source is further away. It can be very difficult to pin point the source of the leak, but don't give up – the analyzer is essentially a leak detector and it is only doing its job.

Another common problem is a reading that is too low. This is normally due either to a dead sensor, or to an incorrect calibration. If the span gas is contaminated with oxygen, when you span the analyzer you will turn the span down too much to make the reading come out to what you thought it should be. It can be hard to figure this one out: what we suggest when things seem to be confusing is that you perform a rapid air calibration, taking less than a minute of air exposure, and then let the sensor stabilize on the sample gas (or nitrogen); then flow the span gas and see what the analyzer reads. The sensor and analyzer are in fact very linear, so if the analyzer now says that the span gas has a lot more oxygen than the label on the tank states, you can be sure that the tank has been contaminated. If so, you have to replace it, and figure out what the reason for the contamination is. Make sure that the regulator is bled properly when you install it, and leak-check all the possible leak sources. And remember that it is always possible for the gas supplier to make a mistake. Incidentally, the air calibration is quite accurate, and you can leave it like that with confidence.

This situation often occurs when you have to use a very low level gas – such as 2ppm oxygen – as the span gas. Unless you treat it with the greatest respect and care you are very likely to have problems. Experience indicates that the best span gas for most applications is 80ppm oxygen in nitrogen. Minor errors or leaks don't change this value too badly, so the resultant calibration is very reliable.

A sure sign of a problem is an unexpected span factor. Check the span factor by pressing the UP button immediately after performing a calibration. If this number is below about 350 it indicates that you have spanned the sensor too low – either you have more oxygen than you think in your span gas, or the sensor hasn't equilibrated to a change in temperature yet. If the number is much greater than the last time the analyzer was calibrated, either the sensor has reached the end of its life or there is some other calibration error. Using the user interface, you can read the previous span factors as well. This number always goes up as the sensor ages (it is changed every time you span the analyzer, it doesn't change by itself). So if it goes down, something is wrong. You have more oxygen in the span gas than you thought, (or there is something wrong with the analyzer, but this doesn't happen often).

Analyzer does not power up.

1. Check that the power is connected correctly.
2. Check that the power supply voltage is between 10.0V and 28VDC.

Analyzer reads too low

1. Sensor is not calibrated. Flow span gas through it and span the analyzer until the analyzer reads appropriately.
2. If you cannot adjust the span enough to accomplish this, replace the sensor.
3. If the new sensor still reads too low, verify the span gas with a suitable reference device such as a portable analyzer.
4. If the sensor seems to die quickly, it may be getting poisoned by acid or sulfur bearing gases such as H_2S. If so, use a higher H2S rated sensor such as a T-4.
5. Verify that the cell block connectors are in fact making contact with the cell. Clean them gently with a Q tip, and bend them slightly straighter so that they make a good contact. Once this is done the cell should have some resistance to being removed from the block.
6. Water may have shorted out the contacts on the back of the sensor. If so, use a Liquid Rejection Probe with a cooling coil or coalescing filter to make sure that condensation does not occur within the analyzer.

Analyzer reads too high

1. Verify that there is no flow restriction in the vent line of the analyzer.
2. Increase the flow rate through analyzer by increasing the sample pressure - if the reading goes down it indicates a leak in the incoming sample line or the cell block. Use “Snoop™” or equivalent to check all the fittings back to the gas source.
3. Leak test all external fittings with “Snoop™” soap solution or equivalent.
4. Verify that the gas flow rate is correct. (0.1 to 2 SCFH)
5. Oxygen diffusion can be a serious problem. Verify that no plastic tubing or other plastic components are used in a trace gas system, including diaphragms of pressure regulators, packing of valves etc. For percent applications, similar problems may be experienced with silicone tubing. Use Teflon™ or Tygon™ or similar high quality tubing.
6. Flow zero gas through the analyzer for a while until the reading is stable: shut off the incoming flow with the sample/span valve and then immediately seal the vent tightly with a tube plug or equivalent (don’t pressurize the cell!). Monitor the reading and see if it increases significantly over a 5 minute period. Such an increase indicates a leak in the cell block or internal sample system.
7. Remove the cell and place it in a cell simulator and verify that the analyzer reads zero - if not, there is moisture or corrosion between the sensor contacts in the cell block; clean the contacts and the area around them with isopropyl alcohol, dry with dry compressed air or nitrogen, then replace the cap on the cell block again. Pressurize the system to no more than 10 psig and leak check all the fittings and tubing including the sensor block penetrations such as the sensor wire seals (nylon plugs and epoxy seals on the top of the cell block).

NOTE: Be careful not to get soap solution on the PC boards!

NOTE: Almost always, high oxygen readings are due to leaks. Oxygen in the air is under a partial pressure of about 5 psia at sea level, and thus will force its way into minute leaks, no matter what the internal pressure of any other gas may be. 3000 psig nitrogen or other gas lines look like a vacuum to oxygen! This always surprises people who have not experienced it.

Analyzer reads zero

1. Verify that the sensor is in the correct position, not upside down. If it is upside down, verify that the membrane has not been punctured - i.e. there is no sign of electrolyte on the surface, and if not, put it back the right way up. If you have left it this way for a while, it may take several hours to recover to a low reading.
2. Verify that the cell block contacts are touching the sensor. Pull the sensor tab, and the contact should hold the sensor with a gentle force. If not, the contacts may be bent. If they have been bent too much, remove the sensor and gently bend them back so that they can again make contact.

3. Make sure that the gold plated contact wires are clean. If not, gently clean them with a Q tip or an eraser. Do not use an abrasive cleaner, as it will remove the gold plating.
4. Check the output of the sensor with a DVM configured to measure current. Connect its leads to the two gold rings on the back of the sensor - the center is ground. The output should be around 150 to 750 micro Amps in air. This will take a few minutes to stabilize as the sensor consumes oxygen dissolved in its electrolyte. Replace the sensor if it does not read this amount. See sensor replacement instructions under Maintenance.

Incorrect readings

1. Verify that there are no leaks in the system.
2. Verify that the span gas bottle is correctly marked by comparing its reading when the analyzer has been spanned on air to what it actually says.

Still no correct operation

1. Call AMI at 714 848 5533, and ask for Technical assistance.
2. Or contact us by email at sales@AMIO2.com.

Specifications and Disclaimer

Specifications:

- **10 user selectable output ranges to choose from:** 0-10ppm, 0-50ppm, 0-100ppm, 0-500ppm, 0-1000ppm,0-.500%, 0-1%, 0-5%, 0-10% and 0-25%. The selection of an output range simultaneously controls the datalog so that both functions operate on the same range
- **Digital display:** 3 digit LCD. Reads full scale from 0.05ppm to 25.0% independently of output range selection
- **Isolated analog output signal:** 1-5VDC or 4-20mA represents the output range selected
- **Power requirements:** 10-28VDC <50mA. @ 12VDC
- **Minimum detection:** 50ppb of oxygen
- **Repeatability:** +/- 1% of range or +/- 0.2ppm of oxygen, whichever is greater
- **Operating temperature range:** 25 to 115˚ F
- **Diurnal temperature specification:** < +/- 3 % of scale over temperature range
- **90% upscale response times:** 10ppm – 25% <10 seconds; 0-10ppm < 25 seconds
- **Typical downscale response:** 1 minute exposure to air down to 10ppm: < 15 minutes
- **Area Classification:** Designed to meet requirements for Class 1, Div. 2, Groups C,D applications
- **Inlet gas pressure:** 0.5 to 150psig
- **Gas connections:** ¼" 316 S.S. compression fittings.
- **Wetted parts:** 316 S.S. fittings, electroless nickel plated cellblock, gold plated contacts, acrylic flow meter and Viton O-rings
- **Unaffected by changes in flow rate** from 0.1 to 2.0 SCFH
- **Mounting:** Wall mount or 2.0" pipe
- **Dimensions:** 7.0"W x 6.5"H x 4.5"D
- **Weight:** 6 lbs.

Disclaimer

Although every effort has been made to assure that the AMI analyzers meet all their performance specifications, AMI takes no responsibility for any losses incurred by reason of the failure of its analyzers or associated components. AMI's obligation is expressly limited to the analyzer itself.

The AMI analyzer is not designed as a primary safety device, that is to say it is not to be used as the primary means of assuring personnel safety. In particular it is not designed to act as a medical instrument, monitoring breathing air for correct oxygen concentration, and should not be used as such when it is the only safety device on the gas system.

AMI® WARRANTY & SUPPORT

LIMITED WARRANTY/DISCLAIMER

The warranty period is **TWO YEARS** for the Analyzer. Any failure of material or workmanship will be repaired free of charge for that specified period from the original purchase (shipping date) of the instrument. AMI will also pay for 1-way ground shipment back to the customer.

The warranty period for the electrochemical oxygen sensor is 6 months.

The warranty period for the electrochemical H_2S sensor is 6 months.

The warranty period for the zirconium oxide sensor is 2 years.

Any indication of abuse or tampering of the instrument will void the warranty.

Receiving the Analyzer
When you receive the instrument, check the package for evidence of damage and if any is found contact the shipper. Although every effort has been made to assure that the Analyzer meets all performance specifications, AMI takes no responsibility for any losses incurred by reason of the failure of this analyzer or associated components. AMI's obligation is expressly limited to the Analyzer itself.

EXCEPT FOR THE FOREGOING LIMITED WARRANTY, AMI MAKES NO WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, AS TO THE NON-INFRINGEMENT OF THIRD-PARTY RIGHTS, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE. IF APPICABLE LAW REQUIRES ANY WARRANTIES WITH RESPECT TO THE SYSTEM, ALL SUCH WARRANTIES ARE LIMITED IN DURATION TO TWO (2) YEARS FROM THE DATE OF DELIVERY.

LIMITATION OF LIABILITY

IN NO EVENT WILL AMI BE LIABLE TO YOU FOR ANY SPECIAL DAMAGES, INCLUDING ANY LOST PROFITS, LOST SAVINGS, OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF THE COMPANY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, OR FOR ANY CLAIM BY ANY OTHER PARTY.

LIMITATION OF REMEDIES

AMI's entire liability and your exclusive remedy under the Limited Warranty (see above) shall be the replacement of any Analyzer that is returned to the Company and does not meet the Company's Limited Warranty.