
OPERATING INSTRUCTIONS FOR

MODEL BDS-3960

Oxygen Analyzer



P/N M71903
9/04/02
ECO # 02-232



DANGER



Toxic gases and or flammable liquids may be present in this monitoring system.
Personal protective equipment may be required when servicing this instrument.
Hazardous voltages exist on certain components internally which may persist for a time even after the power is turned off and disconnected.
Only authorized personnel should conduct maintenance and/or servicing.
Before conducting any maintenance or servicing, consult with authorized supervisor/manager.

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Warranty

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

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

Important Notice

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

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

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

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

Oxygen Analyzer

Specific Model Information

The instrument for which this manual was supplied may incorporate one or more options not supplied in the standard instrument. Commonly available options are listed below, with check boxes. Any that are incorporated in the instrument for which this manual is supplied are indicated by a check mark in the box.

Instrument Serial Number: _____

Options Included in the Instrument with the Above Serial Number:

- **220 VAC:** Instrument configured 200-240 VAC, 50/60Hz power

Safety Messages

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:



GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger. These cautions warn of specific procedures which if not followed could cause bodily injury and/or damage the instrument.



CAUTION: HOT SURFACE WARNING: This warning is specific to heated components within the instrument. Failure to heed the warning could result in serious burns to skin and underlying tissue.



WARNING: ELECTRICAL SHOCK HAZARD: Dangerous voltages appear within this instrument. This warning is specific to an electrical hazard existing at or nearby the component or procedure under discussion. Failure to heed this warning could result in injury and/or death from electrocution.



Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.

No
Symbol

NOTE: Additional information and comments regarding a specific component or procedure are highlighted in the form of a note.

CAUTION: THE ANALYZER SHOULD ONLY BE USED FOR THE PURPOSE AND IN THE MANNER DESCRIBED IN THIS MANUAL.



IF YOU USE THE ANALYZER IN A MANNER OTHER THAN THAT FOR WHICH IT WAS INTENDED, UNPREDICTABLE BEHAVIOR COULD RESULT POSSIBLY ACCOMPANIED WITH HAZARDOUS CONSEQUENCES.

This manual provides information designed to guide you through the installation, calibration and operation of your new analyzer. Please read this manual and keep it available.

Occasionally, some instruments are customized for a particular application or features and/or options added per customer requests. Please check the front of this manual for any additional information in the form of an Addendum which discusses specific information, procedures, cautions and warnings that may be peculiar to your instrument.

Manuals do get lost. Additional manuals can be obtained from Teledyne at the address given in the Appendix. Some of our manuals are available in electronic form via the internet. Please visit our website at: www.teledyne-ai.com.

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This is a general purpose instrument designed for usage in a nonhazardous area. It is the customer's responsibility to ensure safety especially when combustible gases are being analyzed since the potential of gas leaks always exist.

The customer should ensure that the principles of operating of this equipment is well understood by the user. Misuse of this product in any manner, tampering with its components, or unauthorized substitution of any component may adversely affect the safety of this instrument.

Since the use of this instrument is beyond the control of Teledyne, no responsibility by Teledyne, its affiliates, and agents for damage or injury from misuse or neglect of this equipment is implied or assumed.

Introduction

1.1 Overview

The Teledyne Analytical Instruments Model BDS 3960 Oxygen Analyzer is a versatile instrument for detecting oxygen at the parts-per-billion (ppb) level in a variety of gases. This manual covers the Model BDS 3960 General Purpose flush-panel and/or rack-mount units only. These units are for indoor use in a non-hazardous environment.

1.2 Typical Applications

A few typical applications of the Model BDS 3960 are:

- Monitoring inert gas blanketing
- Air separation and liquefaction
- Chemical reaction monitoring
- Semiconductor manufacturing
- Petrochemical process control
- Quality assurance
- Gas analysis certification.

1.3 Main Features of the Analyzer

The Model BDS 3960 Oxygen Analyzer is sophisticated yet simple to use. The main features of the analyzer include:

- Pocket PC with Windows CE operating system used as a controller for analyzer functions.
- High resolution, accurate readings of oxygen content from low ppb levels through 100 ppm. Large, bright, meter readout.
- New BDS Sensing technology, patent pending.
- Versatile analysis over a wide range of applications.
- Microprocessor based electronics: 8-bit CMOS microprocessor with 32 kB RAM and 8 kB ROM for I/O operations.



- Three user definable output ranges (from 0-100 ppb through 0-100 ppm) allow best match to users process and equipment, plus a fixed 100 ppm over range.
- Auto Ranging allows analyzer to automatically select the proper preset range for a given measurement. Manual override allows the user to lock on to a specific range of interest.
- Two adjustable concentration alarms and a system failure alarm.
- Two way RFI protection.
- Four analog outputs: two for measurement (0–1 VDC and Isolated 4–20 mA DC) and two for range identification.
- Convenient and versatile, steel, flush-panel or rack-mountable case with slide-out electronics drawer.

1.4 Front Panel (Operator Interface)

The standard BDS 3960 is housed in a rugged metal case with all controls and displays accessible from the front panel. See Figure 1-1. The front panel has the pocket PC, a digital meter, an alphanumeric display, and a window for viewing the sample flowmeter.

There are no keys to press on the front panel. All interface with the analyzer is done through the touchscreen of the pocket PC. The main functions on the touchscreen are listed below.

- **System** Perform system-related tasks (described in detail in chapter 4, *Operation*.).
- **Span** Span calibrate the analyzer.
- **Zero** Zero calibrate the analyzer.
- **Alarms** Set the alarm setpoints and attributes for Alarm 1 and Alarm 2.
- **Range** Set up the 3 user definable ranges for the instrument.
- **Quit** Quit analyzer application.

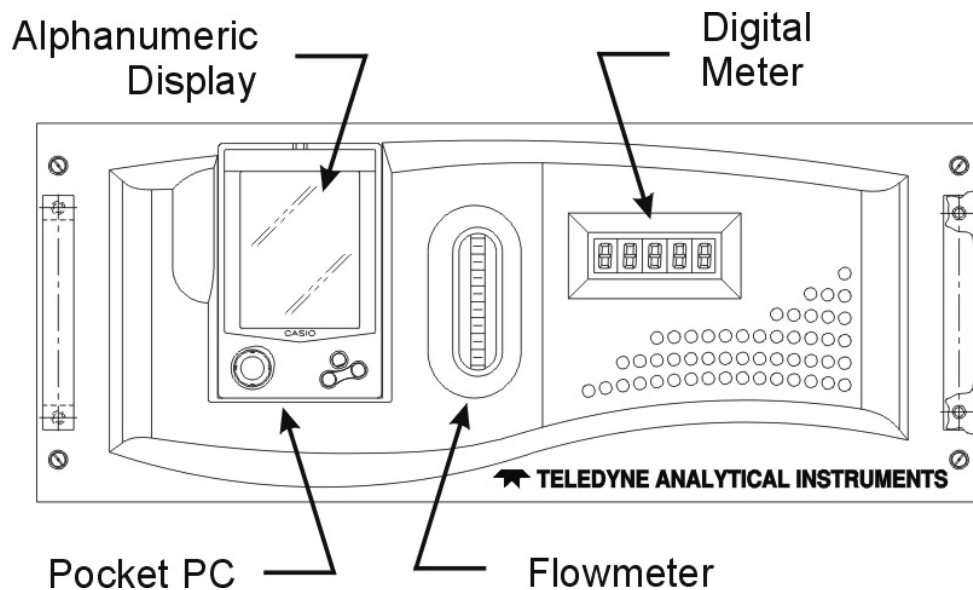


Figure 1-1: BDS-3960 Front Panel

Digital Meter Display: The meter display is a Light Emitting Diode (LED) device that produces large, bright, 7-segment numbers that are legible in any lighting. It produces a continuous readout from 0-999.9 ppb and then switches to a continuous ppm readout from 0-100.00 ppm. It is accurate across all analysis ranges without the discontinuity inherent in analog range switching.

Flowmeter: Monitors the flow of gas past the sensor. Readout is 0.1 to 2.0 standard liters per minute (SLPM) of nitrogen

CAUTION:



THE POWER CABLE MUST BE UNPLUGGED TO FULLY DISCONNECT POWER FROM THE INSTRUMENT. WHEN CHASSIS IS EXPOSED OR WHEN ACCESS DOOR IS OPEN AND POWER CABLE IS CONNECTED, USE EXTRA CARE TO AVOID CONTACT WITH LIVE ELECTRICAL CIRCUITS.

Access Drawer: For access to the BDS Sensor And pressure regulator. The front panel slides out when the four thumb screws are loosened. Opening the interior gives access to most circuit boards too.

1.5 Rear Panel (Equipment Interface)

The rear panel, shown in Figure 1-2, contains the gas and electrical connectors for external inlets and outlets. The connectors are described briefly here and in detail in Chapter 3 *Installation*. Except for gas, AC power, and RS-232 communications I/O, all user connections for analog output, alarms, calibration and remote probe contacts are available through the 50 pin equipment interface connector. User connections made at the rear panel include:

- **Power Connection** 110 VAC power source (220 VAC optional).
 - **Gas Inlet and Outlet** One inlet and one exhaust out.
 - **Moisture By-pass** Additional vent line for condensate
 - **Analog Outputs** 0–1 VDC oxygen concentration plus 0-1 VDC range ID, and isolated 4–20 mA DC oxygen concentration plus 4-20 mA DC range ID.
 - **Alarm Connections** 2 concentration alarms and 1 system alarm.
 - **Remote Probe** Used in the BDS 3960 for controlling external solenoid valves only.
 - **Remote Span/Zero** Digital inputs allow external control of analyzer calibration.
 - **Calibration Contact** To notify external equipment that instrument is being calibrated and readings are not monitoring sample. •
- Range ID Contacts** Four separate, dedicated, range relay contacts. Low, Medium, High, Cal.

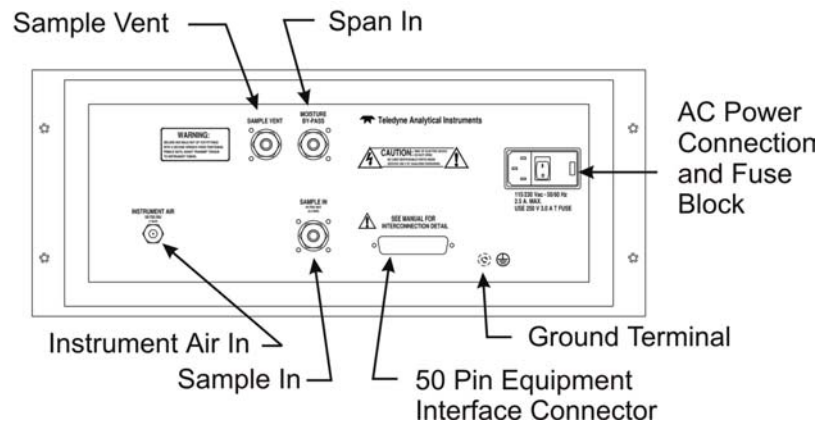


Figure 1-2: Model BDS 3960 Rear Panel

Operational Theory

2.1 Introduction

The analyzer is composed of four subsystems:

- BDS Sensor
- Sample System
- Pocket PC
- Electronic I/O Signal Processing and Display

The sample system is designed to accept the sample gas and transport it through the analyzer without contaminating or altering the sample prior to analysis. The BDS Sensor is an electrochemical device that translates the amount of oxygen present in the sample into an electrical current. The Pocket PC processes the sensor signal and sends messages to the I/O electronics to correctly display oxygen value as well as control other signals to the customer interface. The Electronic I/O signal processing amplifies the sensor signal, digitizes the sensor reading and sends them to the pocket PC for processing. Then it receives commands from the pocket PC to manipulate signals for the customer interface.

2.2 BDS Sensor

2.2.1 Principles of Operation

The BDS oxygen sensor technology developed at Teledyne Analytical Instruments is a result of TAI's heavy investment on R&D and expertise established during the half-century's manufacturing of electrochemical oxygen sensor. It stands for Bipotentiostat Driven Sensor. A BDS oxygen sensor accurately translates the oxygen level in the sample gas into to an electrical current signal.

A potentiostat contains three electrodes: a working electrode, a reference electrode and a counter electrode. A Bipotentiostat is a combination of two potentiostats that share the reference electrode and the counter electrode. The potential at the working electrode is precisely

controlled with respect to the reference electrode. The counter electrode is used to carry the current that flow through the sensor. A potentiostat is typically constructed with several operational amplifiers. The three electrodes in an electrochemical cell and the operational amplifiers in the potentiostat constitute a feedback-control loop. The potentiostat technology has been well accepted in the field of electrochemistry, and proven effective in eliminating polarization of the reference electrode and automatic compensating electric resistance in the cell.

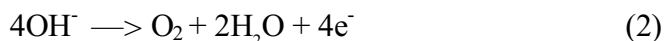
In a BDS oxygen sensor, the sensing electrode is a working electrode that is under precise potential control as discussed above. A stable sensing electrode potential is very critical for an oxygen sensor to achieve high stability, low noise and large dynamic range. The reference electrode in a BDS sensor is a Ag/Ag₂O electrode which is well known for its stable electrode potential and compatibility with the KOH electrolyte in an oxygen sensor. The counter electrode is made of a Platinum wire.

The sensing process involves electrochemical reactions inside the sensor. At the sensing electrode, oxygen is reduced at the controlled potential:



There is no net electrochemical reaction at the reference electrode since it is connected to the high impedance input of the operation amplifier.

The electrochemical reaction at the counter electrode is:



It is noteworthy that reaction (2) is reverse of the reaction (1). It is indicative of a net change of zero inside a BDS sensor throughout the sensing process. This feature produces a long-term stability for the BDS sensor.

There are two resources of oxygen being reduced at the sensing electrode: from the sample gas and dissolved oxygen within the electrolyte. The oxygen molecules in the sample gas diffuse to the sensing electrode through a diffusion barrier (controlled diffusion) to produce a current signal which is proportional to the oxygen level in the sample gas. However, the dissolved oxygen in the electrolyte also diffuses through the electrolyte. It is reduced at the sensing electrode and produces a background current. This background current represents the detection limit of an oxygen sensor.

The main advantage of the BDS technology lies in the unique second potentiostat. It is designed to remove dissolved oxygen and other impurities in the electrolyte. It eliminates the internal background current which previously limited the detection process.

The second potentiostat is located adjacent to the sensing electrode. It uses a novel material, Reticulated Vitreous Carbon (RVC) and precise control of the potential to remove the dissolved oxygen and impurities in the electrolyte efficiently. As the result, the BDS sensor achieves an outstanding feature of absolute zero output in the absence of oxygen.

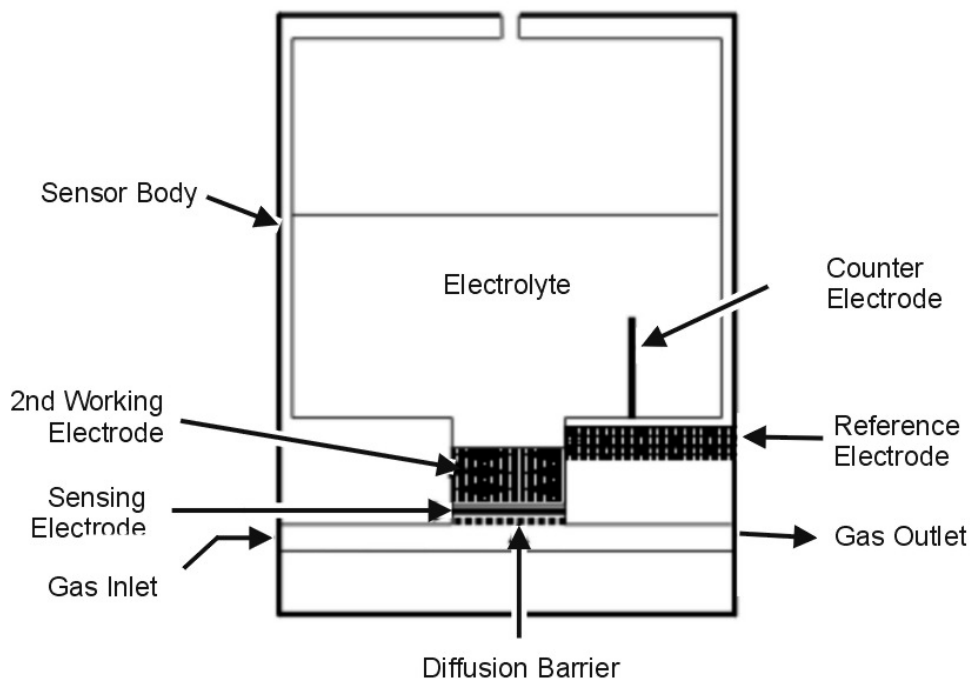


Figure 2.1: Cross Section of the BDS Oxygen Sensor

Figure 2.1 shows the schematic of a BDS oxygen sensor. The sample gas enters the sensor through the gas inlet port and exits at the gas outlet. A portion of oxygen in the sample gas diffuses through the diffusion barrier to be reduced at the sensing electrode to form OH^- in the electrolyte. OH^- can move freely through the porous 2nd working electrode. At the counter electrode, OH^- is oxidized back to oxygen.

While the 2nd working electrode allows OH^- to move through, it prevents the dissolved oxygen from the top portion of the sensor to reach the sensing electrode. The reference electrode provides a potential reference for both the sensing electrode and the 2nd working electrode.

NOTE: BDS technology and sensor is a patent pending technology of Teledyne Analytical Instruments in the United State of America as well as many foreign countries.

To learn more about BDS technology, please visit TAI's web page at <http://www.Teledyne-AI.com>

To learn more about potentiostat, visit Electrochemical Society's web page at <http://www.electrochem.org>

2.2.2 Gas Flow Rate

The output from a BDS oxygen sensor is relatively insensitive to change of gas flow rate if operated in the range of 1 - 3 SCFH (in nitrogen). The output drops when the flow rate is below 1 SCFH. Figure 2.2 is a typical curve showing the sensor outputs at different flow rate.

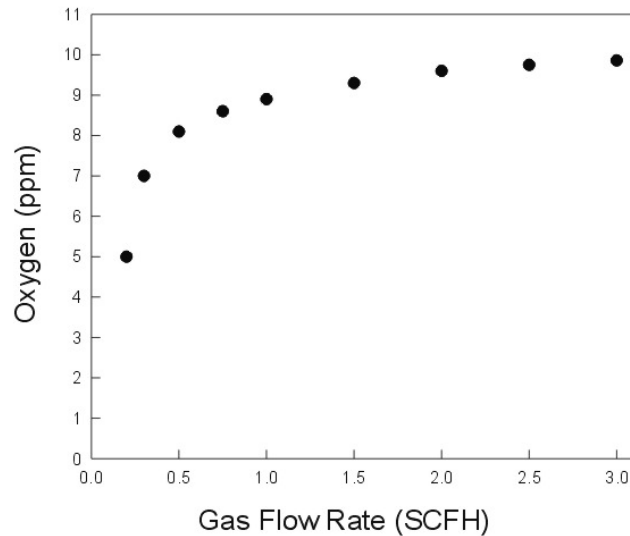


Figure 2.2: BDS sensor output at different gas flow rate

2.2.3 Gas Pressure

The analyzer is equipped with a pressure regulator as shown in Figure 2-3. To access the pressure regulator, the front panel must be opened. The inlet pressure should be regulated anywhere between 4 to 50 psig. The sensor is not affected by pressure changes in the inlet as long as the analyzer vents to atmosphere. If the analyzer is not vented to atmosphere, the downstream pressure must not exceed 10 inch of water. A clogged or restricted vent or excessive pressure will force gas into the electrolyte and cause damage to the BDS sensor.

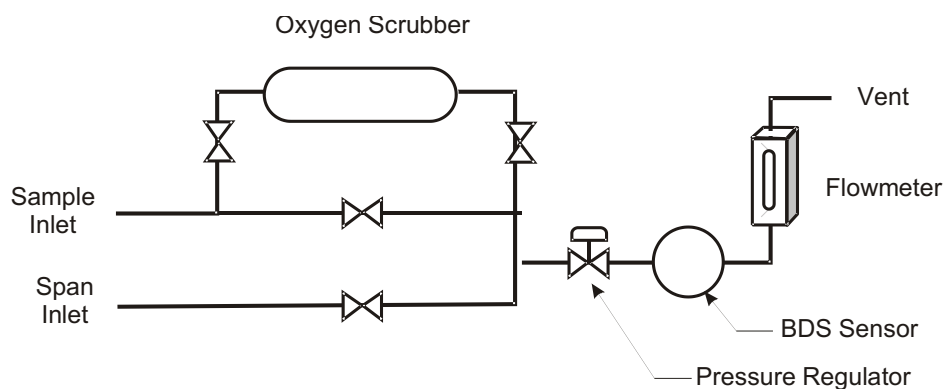


Figure 2-3: A simplified BDS Sample System

2.2.4 Temperature effect

The raw output from a BDS oxygen sensor has a temperature coefficient about 0.25% / °C. That is an average value, it changes as temperature changes. This temperature effect is compensated by the software throughout the operation temperature range (5 – 40°C).

2.2.5 Recovery from High Level Oxygen Exposure

The ambient air contains about 210,000,000 ppb (2.1×10^8) oxygen. Figure 2.4 is a typical purge-down curve for a new BDS sensor which had been air saturated. It is normal to take several hours, even days for an air saturated BDS to purge down to a low ppb level.

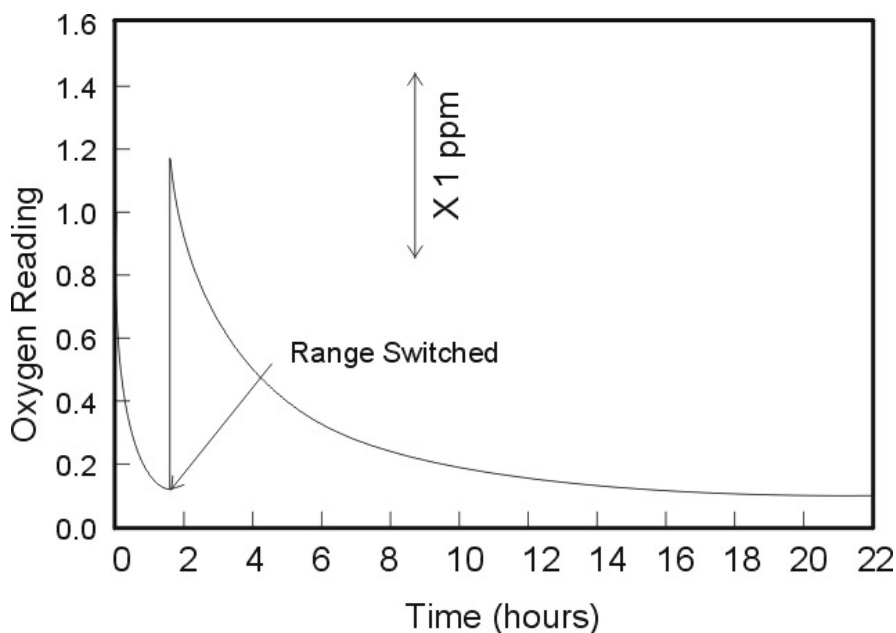


Figure 2.4 Typical Purge-down Curve After Air Saturation

Shortening the air exposure will allow a faster sensor recovery. A typical BDS sensor will recover to 1 ppm in approximately 25 minutes, to 100 ppb after 80 min, and 10 ppb in about 8 hours, after suffering a ten-minute exposure to air.

2.2.6 Background Gas Compatibility

The BDS oxygen sensor will work in inert gas backgrounds, including nitrogen, hydrogen, argon, helium and ethane. The sensor output, however, is different in different background gases. For example, the sensor output in a hydrogen background is twice as much as it would be in a nitrogen background. Therefore, it is recommended to calibrate the analyzer with an oxygen standard that has a similar background as the sample gas. If an oxygen standard is unavailable for a particular background, a Gas Factor which is determined at TAI could be used to correct the sensor output in different background (see section 4.3.9).

Note: the gas flow meter in the analyzer is calibrated for air. The error for measuring nitrogen is usually negligible. But for

hydrogen, it reads 100% lower. For example, when the float ball in the flowmeter is at 0.5 SLPM, the actual flow rate of hydrogen is about 1 SLPM.

The BDS oxygen sensor can tolerate exposure to acidic gases. Up to 0.2% CO₂ has no effect to ppb level oxygen measurement.

2.2.7 Stability

The BDS sensor is essentially drift free. Typically a BDS sensor requires no re-calibration over an entire year period. However, there may be some intrusion to the zero during the maintenance. See next section for details.

2.2.8 Maintenance

The only maintenance required on the BDS sensor is to replenish distilled or de-ionized water every three to four months. It is not necessary to take the analyzer out of service while adding water to the sensor but caution should be taken to avoid spilling water on the PC boards or other area inside the analyzer.

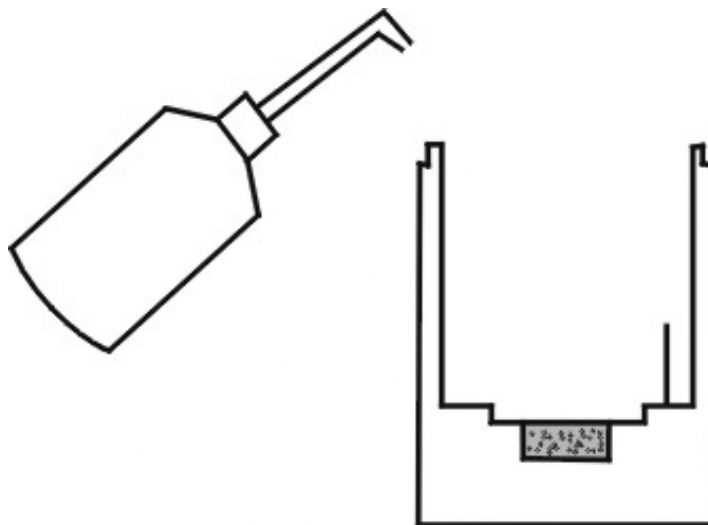


Figure 2.5: Adding DI Water to the BDS Sensor

There is a Max line and Min Line clearly marked on the BDS sensor body. It is a good practice to check the electrolyte level every month and add de-ionized water into the sensor whenever it is convenient.

When running dry gas through the sensor, the gas carries out moisture from the sensor. Therefore, the electrolyte (10% KOH in water) inside the sensor is gradually concentrated during the sensor operation. It typically takes about four months for the electrolyte level to drop from the Max line to Min line. When adding water to increase the electrolyte level from the Min line to the Max line, it is typical that the oxygen reading will drift down about 10 ppb in an hour. If the oxygen content in the sample gas is very close to zero, the analyzer may display a negative reading during this period. The sensor will recover by itself during the following week. This drift-down then recover-back phenomenon is caused by the quick dilution of the electrolyte and re-establishment of a new equilibrium inside the sensor. To minimize this effect, add a small amount of water each time and do this before the electrolyte level reaches the Min line.

2.3 Sample System

The sample system delivers gases to the BDS sensor from the analyzer rear panel inlet. Depending on the mode of operation either sample or calibration gas is delivered.

The Model BDS 3960 sample system is designed and fabricated to ensure that the oxygen concentration of the gas is not altered as it travels through the sample system.

The sample system for the standard instrument incorporates 1/4" VCR fittings for sample inlet, span inlet, and vent and Swagelock fittings for instrument air tube connections at the rear panel. The sample or calibration gas that flows through the system is monitored by a flowmeter downstream from the sensor.

Figure 2-6 represents the flow diagram of the sampling system. In the standard instrument, span gases can be connected to its own separate inlet port. Solenoid valves are controlled by the software to switch the proper gas when the analyzer enters the span mode. Zero gas is generated internally when the sample gas is re-routed to go through an oxygen scrubber before it is fed to the sensor. The life of the oxygen sensor depends in two main factors: flow rate, oxygen impurity being scrubbed. Thus, the life of the scrubber can vary depending on the sample gas being used to zero the analyzer. It is recommended to change the oxygen scrubber every two years. Use this as a guideline only.



Note that instrument air at a pressure of 70 to 80 psig is needed to activate the proper valves.

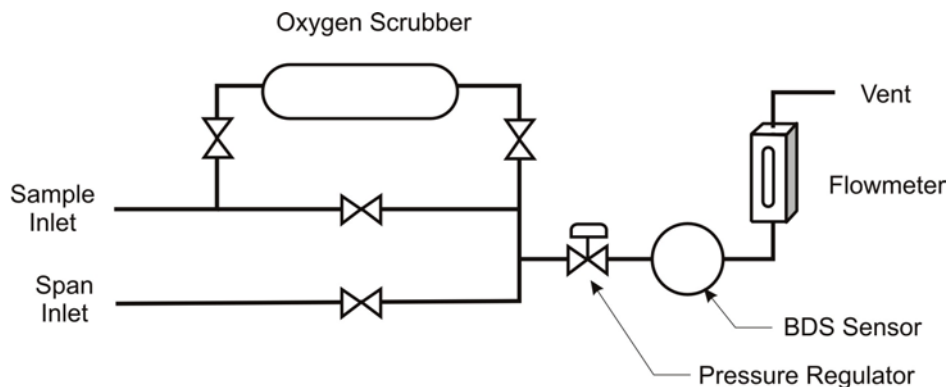


Figure 2-6: Flow Diagram

2.4 Electronics and Signal Processing

The Model BDS 3960 Oxygen Analyzer uses an 8051 microcontroller with 32 kB of RAM and 8 kB of ROM to control signal processing, input/output, and display functions for the analyzer. Most of the processing power and decision making is done by the software running on the pocket PC (PPC). System power is supplied from a universal power supply module designed to be compatible with any international power source.

The signal processing electronics including the microprocessor, analog to digital, and digital to analog converters are located on the I/O board at the bottom of the case. The preamplifier board is mounted on top of the I/O board. These boards are accessible by sliding the front out. Figure 2-7 shows a block diagram of the analyzer electronics.

In the presence of oxygen the sensor generates a current. A current to voltage amplifier converts this current to a voltage which is further amplified in the second stage amplifier.

The output from the second stage amplifier is sent to an 12 bit analog to digital converter that is located in the same chip as the microprocessor. The amplifier board also reads the ambient temperature

as the signal is passed to a second channel of the analog to digital converter.

The raw counts of the analog to digital converter for both the oxygen sensor amplifier and temperature amplifier are sent to the PPC via RS232 interface once every second along with a status byte. The PPC performs processing on this data to calculate oxygen concentration, temperature, as well as decisions regarding the condition of the alarm contacts, range, amplifier gain, solenoid control, and the analog output required. After processing, the PPC sends a message back to I/O board, via RS232, with commands for all the I/O functions. The 8051 microprocessor in the I/O board evaluates this data and the appropriate control signals are directed to the LED display, alarms contacts, range ID contacts, and digital to analog converter. The analog to digital converter is a 12 bit device located in the microprocessor IC. The output of the digital to analog converter with the help of some support electronics produces the 4-20 mA DC and the 0-1 VDC analog concentration signal outputs.

Signals from the power supply are also monitored, and through the microprocessor, the system failure alarm is activated if a malfunction is detected. Failure to communicate with the PPC will also trigger the System alarm.

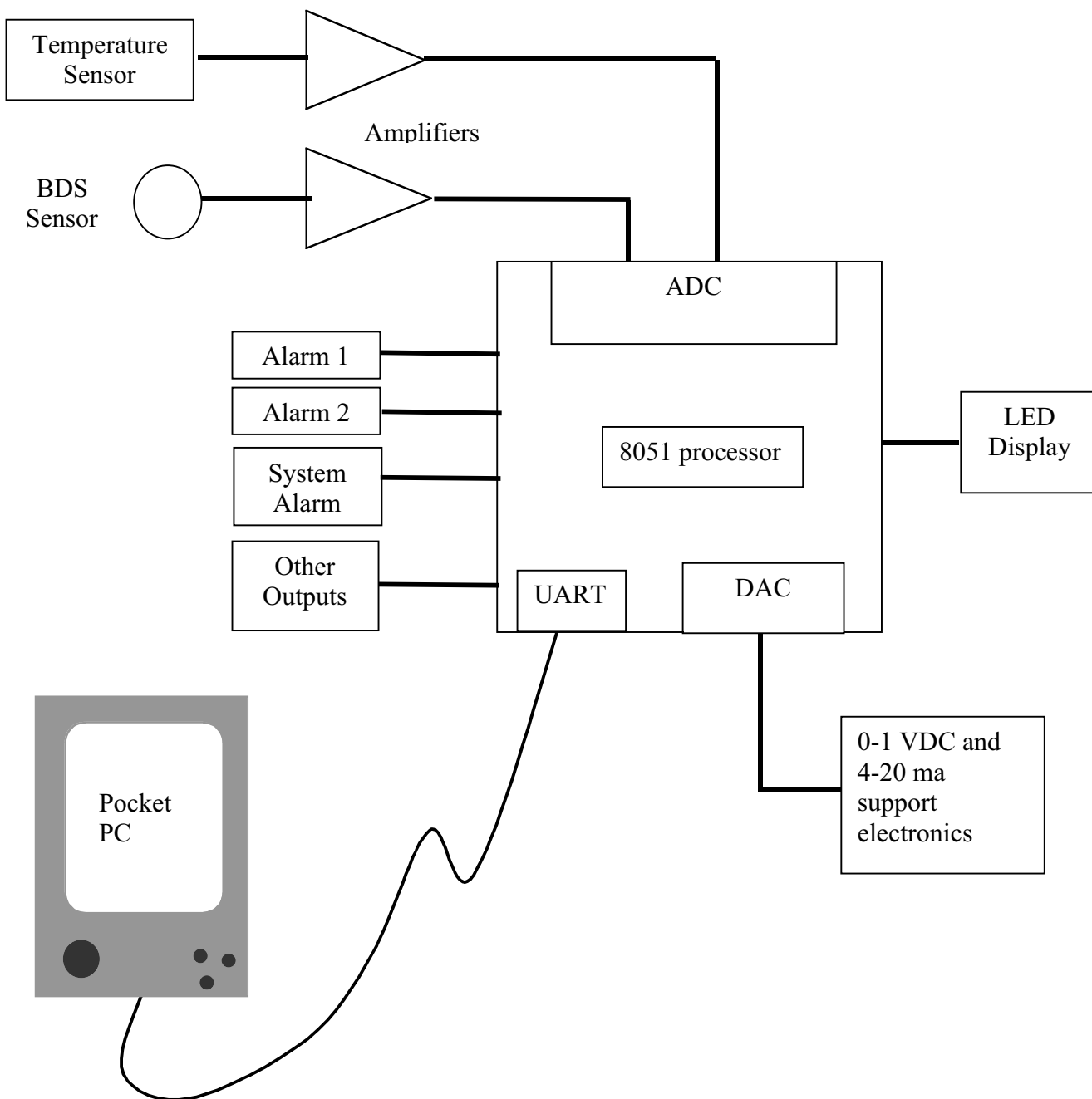


Figure 2-7: BDS 3960 Electronics Block Diagram

Installation

Installation of the Model BDS 3960 Analyzer includes:

- Unpacking
- Mounting
- Gas connections
- Electrical connections
- Filling the Sensor with Electrolyte.
- Testing the system.

3.1 Unpacking the Analyzer

Although the analyzer is shipped complete, certain parts, such as the electrolyte, are wrapped separately to be installed on site as part of the installation. Carefully unpack the analyzer and inspect it for damage. Immediately report any damage or shortages to the shipping agent.

3.2 Mounting the Analyzer

The Model BDS 3960 is for indoor use in a general purpose area. It is NOT for hazardous environments of any type.

The standard model is designed for flush panel mounting. Figure 3-1 is an illustration of the BDS 3960 standard front panel and mounting bezel. There are four mounting holes—one in each corner of the rigid frame. The drawings section in the rear of this manual contains outline dimensions and mounting hole spacing diagrams.

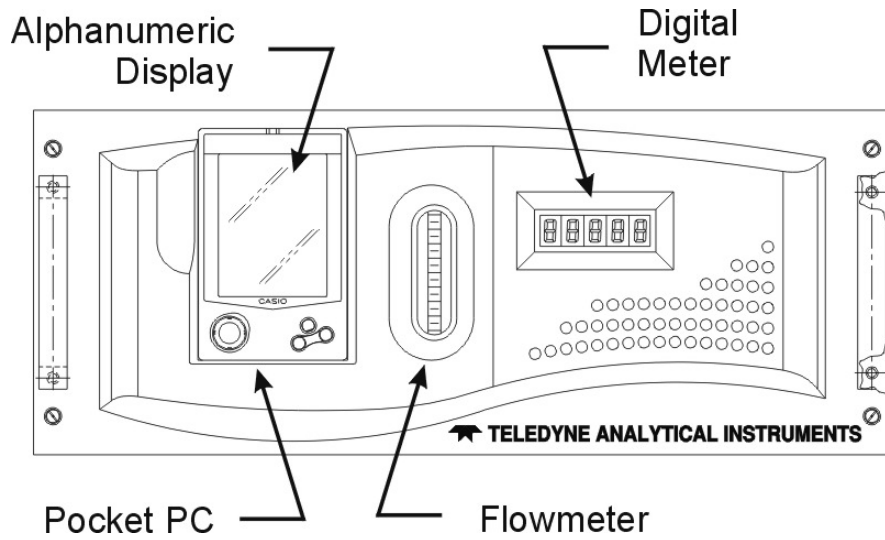


Figure 3-1: Model BDS 3960 Front Panel

Access to the electronics, the sensor, and sampling system is accomplished by loosening the thumbscrews on the front of the analyzer. The whole assembly will slide out toward the front. Allow clearance for the assembly to slide out when maintenance is required. Leave clearance of about 20 inches so that whole assembly can be pulled out of its case. See Figure 3-2.

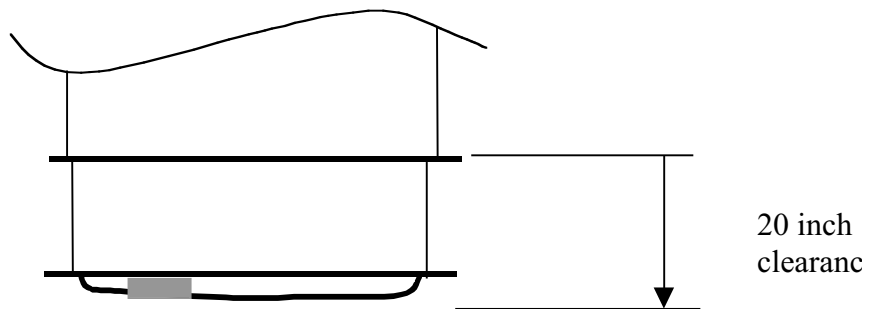


Figure 3-2: Required Assembly Drawer Clearance

3.3 Rear Panel Connections

Figure 3-3 shows the Model BDS 3960 rear panel. There are ports for gas inlet and outlet, power, communication, and analog concentration output.

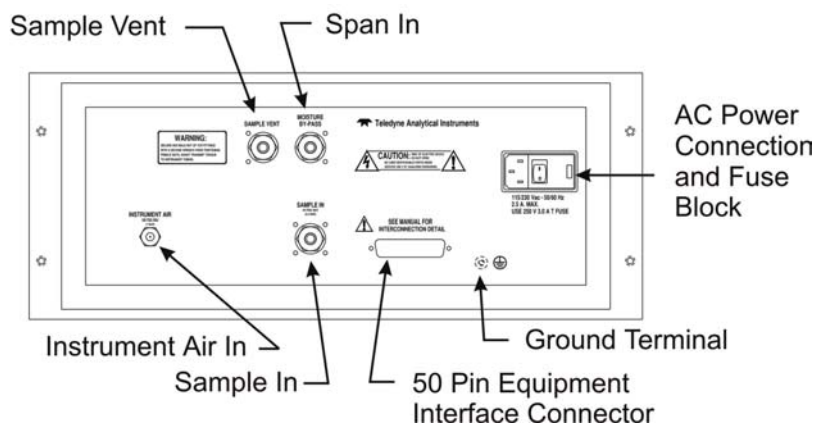


Figure 3-3: Rear Panel of the Model BDS 3960

3.3.1 Gas Connections

The unit is manufactured with 1/4 inch VCR fittings with the exception of instrument air fitting. All of the gas connections are located on the rear of the analyzer. For all VCR fittings, insert a gasket (TAI PN G284) between the fittings and tighten the female and male nuts until fingertight; then by holding the male nut with a wrench, tighten the female nut with a second wrench an additional 1/6 turn.

SAMPLE IN: The gas of interest connections are made at the SAMPLE IN and EXHAUST OUT connections. For zero calibration, the sample gas is rerouted through an oxygen scrubber to supply oxygen-free zero cal gas. A VCR fitting is provided for the inlet connection.

The inlet gas pressure should be regulated to pressures between 5 to 50 psig so that the internal regulator can be adjusted to maintain a flow between 0.5 to 1.0 SLPM. If pressure is too low, the flow will drop below 0.5 SLPM which is below the threshold to which the sensor is sensitive (see Section 2.2.2). If pressure is too high, it will force gas into the electrolyte and cause damage to the sensor. The internal pressure regulator is helpful if the sample pressure varies.

If greater sample flow is required for improved response time, install a bypass in the sampling system upstream of the analyzer input.

SPAN IN: Span gas is connected to this port and it is automatically routed by solenoid valves when the analyzer goes into the span mode. Its pressure should be about the same as the inlet pressure of the sample gas. This will ensure that flow remains unchanged when switching between calibration and sample gases and this in turn increases accuracy of the calibration.

EXHAUST OUT: Exhaust connections must be consistent with the hazard level of the constituent gases. Check Local, State, and Federal laws, and ensure that the exhaust stream vents to an appropriately controlled area, if required.

CAUTION: CONNECT VENT LINES TO 1/4" OR LARGER DIAMETER TUBING.



AIR INLET: The solenoid valves of the sampling system need air pressure to actuate them. Use the compression fitting and 1/4" tubing to connect instrument air (compressed air) with pressure in the range of 70 to 80 psig.

CAUTION: PRESSURE HIGHER THAN 100 PSIG CAN DAMAGE THE SOLENOID VALVES.



3.3.2 *Electrical Connections*

For safe connections, no uninsulated wiring should be able to come in contact with fingers, tools or clothing during normal operation.

CAUTION: USE SHIELDED CABLES. ALSO, USE PLUGS THAT PROVIDE EXCELLENT EMI/RFI PROTECTION. THE PLUG CASE MUST BE CONNECTED TO THE CABLE SHIELD, AND IT MUST BE TIGHTLY FASTENED TO THE ANALYZER WITH ITS FASTENING SCREWS. ULTIMATELY, IT IS THE INSTALLER WHO ENSURES THAT THE CONNECTIONS PROVIDE ADEQUATE EMI/RFI SHIELDING.



3.3.2.1 PRIMARY INPUT POWER

The power cord receptacle and fuse block are located in the same assembly. Insert the power cord into the power cord receptacle.

CAUTION: POWER IS APPLIED TO THE INSTRUMENT'S CIRCUITRY AS LONG AS THE INSTRUMENT IS CONNECTED TO THE POWER SOURCE.



The power supply requires 100–120 VAC, 50/60 Hz power source.

Fuse Installation: The fuse block, at the right of the power cord receptacle, accepts US or European size fuses. A jumper replaces the fuse in whichever fuse receptacle is not used. Fuses may not be installed at the factory. Be sure to install the proper fuse as part of installation. (See *Fuse Replacement* in Chapter 5, *Maintenance*.)

3.3.2.2 50-PIN EQUIPMENT INTERFACE CONNECTOR

Figure 3-4 shows the pin layout of the Equipment Interface connector. The arrangement is shown as seen when the viewer faces the rear panel of the analyzer. The pin numbers for each input/output function are given where each function is described in the paragraphs below.

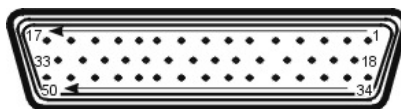


Figure 3-4: Equipment Interface Connector Pin Arrangement

Analog Outputs: There are four DC output signal pins—two pins per output. For polarity, see Table 3-1. The outputs are:

0–1 VDC % of Range: Voltage rises linearly with increasing oxygen, from 0 V at 0 ppm to 1 V at full scale ppm. (Full scale = 100% of programmable range.)

0–1 VDC Range ID: 0.25 V = Low Range, 0.5 V = Medium Range, 0.75 V = High Range, 1 V = 100ppm.

- 4–20 mA DC % Range: Current increases linearly with increasing oxygen, from 4 mA at 0 ppm to 20 mA at full scale ppm. (Full scale = 100% of programmable range.)
- 4–20 mA dc Range ID: 8 mA = Low Range, 12 mA = Medium Range, 16 mA = High Range, 20 mA = 100ppm.

Table 3-1: Analog Output Connections

Pin	Function
3	+ Range ID, 4-20 mA, floating
4	– Range ID, 4-20 mA, floating
5	+ % Range, 4-20 mA, floating
6	– % Range, 4-20 mA, floating
8	+ Range ID, 0-1 V dc
23	– Range ID, 0-1 V dc, negative ground
24	+ % Range, 0-1 V dc
7	– % Range, 0-1 V dc, negative ground

Alarm Relays: The nine alarm-circuit connector pins connect to the internal alarm relay contacts. Each set of three pins provides one set of Form C relay contacts. Each relay has both normally open and normally closed contact connections. The contact connections are shown in Table 3-2. They are capable of switching up to 3 amperes at 250 VAC into a resistive load. The connectors are:

Threshold Alarm 1:

- Can be configured as high (actuates when concentration is above threshold), or low (actuates when concentration is below threshold).
- Can be configured as failsafe or nonfailsafe.
- Can be configured as latching or nonlatching.
- Can be configured out (defeated).

Threshold Alarm 2:

- Can be configured as high (actuates when concentration is above threshold), or low (actuates when concentration is below threshold).
- Can be configured as failsafe or nonfailsafe.
- Can be configured as latching or nonlatching.
- Can be configured out (defeated).

System Alarm:

- Actuates when DC power supplied to circuits is unacceptable in one or more parameters. Permanently configured as failsafe and latching. Cannot be defeated. Actuates if communication with PPC fails.

Further detail can be found in Chapter 4, Section 4-5.

Table 3-2: Alarm Relay Contact Pins

Pin	Contact
45	Threshold Alarm 1, normally closed contact
28	Threshold Alarm 1, moving contact
46	Threshold Alarm 1, normally open contact
42	Threshold Alarm 2, normally closed contact
44	Threshold Alarm 2, moving contact
43	Threshold Alarm 2, normally open contact
36	System Alarm, normally closed contact
20	System Alarm, moving contact
37	System Alarm, normally open contact

Digital Remote Cal Inputs: Accept 0 V (off) or 24 V dc (on) inputs for remote control of calibration. (See *Remote Calibration Protocol* below.) See Table 3-3 for pin connections.

Zero:

- Floating input—5 to 24 V input across the + and – pins puts the analyzer into the Zero mode. Either side may be grounded at the source of the signal. 0 to 1 volt across the terminals allows Zero mode to terminate when done. A synchronous signal must open and close the external zero valve appropriately. See Remote Probe Connector. (The –C option internal valves operate automatically).

Span:

- Floating input—5 to 24 V input across the + and – pins puts the analyzer into the Span mode. Either side may be grounded at the source of the signal. 0 to 1 volt across the terminals allows Span mode to terminate when done. A synchronous signal must open and close external span valve appropriately. See Figure 3-5 Remote Probe Connector. (The –C option internal valves operate automatically.)

Cal Contact:

- This relay contact is closed while analyzer is spanning and/or zeroing. (See Remote Calibration Protocol below.)

Table 3-3: Remote Calibration Connections

Pin	Function
9	+ Remote Zero
11	– Remote Zero
10	+ Remote Span
12	– Remote Span
40	Cal Contact
41	Cal Contact

Remote Calibration Protocol: To properly time the Digital Remote Cal Inputs to the Model BDS 3960 Analyzer, the customer's controller must monitor the Cal Relay Contact.

When the contact is OPEN, the analyzer is analyzing, the Remote Cal Inputs are being polled, and a zero or span command can be sent.

When the contact is CLOSED, the analyzer is already calibrating. It will ignore your request to calibrate, and it will not remember that request.

Once a zero or span command is sent, and acknowledged (contact closes), release it. If the command is continued until after the zero or span is complete, the calibration will repeat and the Cal Relay Contact (CRC) will close again.

For example:

- 1) Test the CRC. When the CRC is open, Send a zero command until the CRC closes (The CRC will quickly close.)
- 2) When the CRC closes, remove the zero command.
- 3) When CRC opens again, send a span command until the CRC closes. (The CRC will quickly close.)
- 4) When the CRC closes, remove the span command.

When CRC opens again, zero and span are done, and the sample is being analyzed.

Note: The Remote Valve connections (described below) provides signals to ensure that the zero and span gas valves will be controlled synchronously.

Range ID Relays: There are four dedicated Range ID relay contacts. The first three ranges are assigned to relays in ascending order—Low range is assigned to Range 1 ID, Medium range is assigned to Range 2 ID, and High range is assigned to Range 3 ID. The fourth range is reserved for the over Range (100 ppm). Table 3-4 lists the pin connections. There is contact opening to indicate what range the analyzer is on. The contacts **open** when the analyzer is on that range.

Table 3-4: Range ID Relay Connections

Pin	Function
21	Range 1 ID Contact
38	Range 1 ID Contact
22	Range 2 ID Contact
39	Range 2 ID Contact
19	Range 3 ID Contact
18	Range 3 ID Contact
34	Range 4 ID Contact (Over range)
35	Range 4 ID Contact (Over range)

3.4 Electrolyte Refill of BDS Sensor

The BDS sensor is shipped dry. It must be filled with the electrolyte before operation. The electrolyte is a caustic solution (10% KOH), supplied in five 50 ml bottles. Review the Material Safety Data Sheet (MSDS) in Section A-6 before handling the electrolyte.

To refill the BDS sensor:

1. Loosen the thumb screws on the front and slide the drawer halfway out.
2. Unscrew the sensor cap and disconnect sensor cable from the BDS sensor.
3. Pour the electrolyte from the five small bottles into a larger container.
4. Sparge the electrolyte with nitrogen gas at a flow of 100 CCM for about 1/2 hour then pour into the provided wash bottle.
5. Ref. to Figure 3.5 for the method of adding electrolyte to the sensor. It is important that as the sensor is being filled with the electrolyte, filling is accomplished without trapping gas bubbles in the lower part of the sensor.
6. Squirt electrolyte content into the sensor. Do it slowly until the bottom parts of the sensor are fully immersed in the electrolyte.



7. Pour the rest of the electrolyte into the sensor. Gas bubbles in the top portion of the sensor do not affect the sensor performance. One bottle of electrolyte is sufficient to rise the electrolyte level to the MAX line. For the rest of sensor life, no further electrolyte addition is needed.
8. Install the sensor cap.
9. Do not connect the sensor's electric connector at this stage.

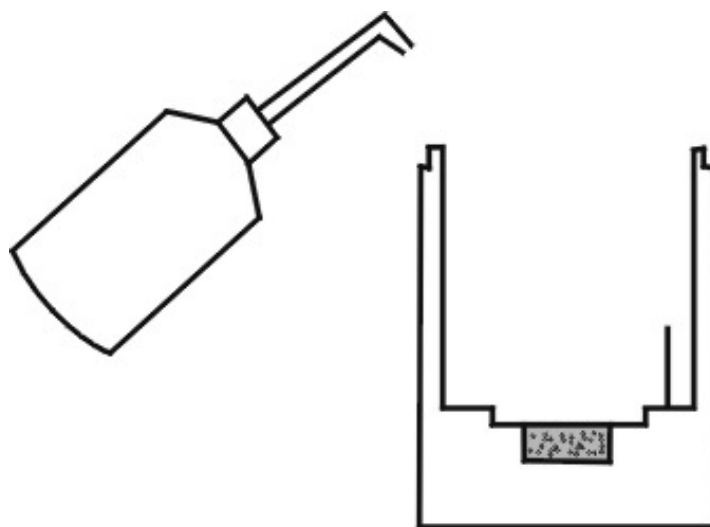


Figure 3.5: Adding Electrolyte to the BDS Sensor

3.5 Testing the System

Before plugging the instrument into the power source:

- Check the integrity and accuracy of the gas connections. Make sure there are no leaks. Gas connection should allow for some movement on the drawer assembly so that the pressure regulator and the sensor connector cable can be reached inside.
- Check the integrity and accuracy of the electrical connections. Make sure there are no exposed conductors
- Check pressure of sample gas as well as instrument air. Set the internal pressure regulator fully counterclockwise.

3.6 Powering Up the System

Before powering up the system, set the pressure regulator to minimum to prevent damage due to incorrect setting. Power up the system by turning on the switch on the rear. Then turn on the PPC by pressing the button on its left side. Make sure that the Analyzer application is running. If the Analyzer application is not running, launch it by following the these steps:

- Tap on *Start* found on the taskbar either at the bottom or the top of the LCD screen of the PPC to pull down a menu.
- Tap on *Programs* to bring up the programs browser.
- Then tap on the *Analyzer* icon found in the browser. This should launch the Analyzer application.
- Adjust the internal pressure regulator until gas flow is in the middle of the flowmeter, around the 1 SLPM mark.
- Purge the sensor for about 15 minutes, then proceed to connect the sensor cable.
- Close the assembly drawer and tighten the thumb screws.
- Purge the analyzer until readings decrease below 50 ppb.



Operation

4.1 Introduction

Once the analyzer has been installed, it can be configured for your application. To do this you will:

- Set system parameters:
- Calibrate the instrument.
- Define the three user-selectable analysis ranges, then choose autoranging or select a fixed range of analysis, as required.
- Set alarm setpoints, and modes of alarm operation (latching, failsafe, etc).

Before you configure your BDS 3960, these default values are in effect:

Ranges: LO = 100ppb , MED = 1000 ppb,
HI = 10 ppm, Over-Range = 100
ppm

Auto Ranging: ON

Alarm Relays: Defeated, Alarm 1 at 1000 ppb,
Alarm 2 at 100 ppb HI, Not
failsafe, Not latching.

4.2 The Analyzer application

The Pocket Personal Computer (PPC) is the brains of the analyzer. The PPC runs the Analyzer program installed by TAI. For the instrument to operate, the program must be launched as instructed in section 3.6.

When the program is launched the main screen will appear as shown below.

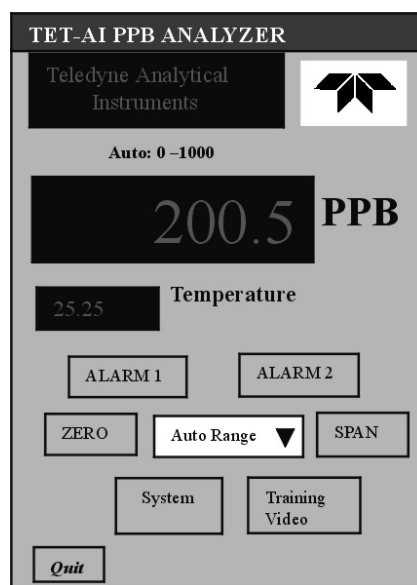


Figure 4-1: Main Menu

The screen shows controls that should be familiar to anyone who has used a personal computer.

- *Alarm 1.* Pressing this button opens a new screen where Alarm 1 trigger point and options can be set.
- *Alarm 2.* Pressing this button opens a new screen where Alarm 2 trigger point and options can be set.
- *Zero.* Pressing this button opens a screen for the zero calibration function.
- *Span.* Pressing this button opens the screen for the span calibration function.

- *System*. Pressing this button will open a second screen that consists of several variables that regulate the internal operations of the analyzer.
- *Training Video*. This buttons launches a video player. At this point you could view a short training video regarding BDS technology. The presentation will time out and return back to the Analyzer application after a period of time.
- *Ranges*. The list box is used to set the analyzer on a specific range as well as set the limits of the ranges.

Any function can be selected at any time by pressing the appropriate button. The order as presented in this manual is appropriate for an initial setup.

Each of these functions is described in greater detail in the following procedures.

4.3 The System Screen

Pressing the *System* button on the main screen will bring the System screen.

The System screen will time out in five minutes and return to the main screen. Pressing the *Done* button will also return you to the main screen.

4.3.1 Communication Information and Calibration Parameters

The first block on the System screen displays information about data received, calibration parameters, and data sent to the I/O hardware.

Received data: 014508900

Zero Offset: 0

Span Factor: 38.00

Amp Gain/Range ID/DAC: 0/0/265

The first line displays the data received from the I/O PCB. It consists of nine digits. The first four digits are the Analog to Digital counts of the BDS sensor amplifier. The range of this count is between 0000 and 4095. The following four digits are the Analog to Digital counts of the temperature

amplifier. The range of this count is the same as the BDS sensor, 0000 to 4095. The last digit is a status digit—zero indicates the I/O PCB is in normal mode. If the I/O PCB receives a remote command to zero or span, it will let the PPC program know through this digit.

Zero Offset line displays the actual Analog to Digital count of the electronics plus sensor offset stored in the memory of the PPC. The lower the number the better, but a high number does not hinder the performance of the sensor very much. One reason for a high count could mean that the sensor is still drifting downward and therefore an additional zero calibration might be needed to maintain accuracy.

Span Factor displays a number which is a factor needed to convert digital counts to PPB oxygen concentration. This number should be between 10 and 40.

AmpGain/RangeID/DAC displays the command sent to the I/O PCB and determines what gain the amplifier should have and what range ID contact should open. Both numbers are from 0 to 4. Usually, with default ranges, they should be the same but not necessarily.

DAC is a count number sent to the analog to digital converter of the I/O PCB. This sets the output for the concentration 0-1 vdc and 4-20 mdc outputs. Its range is from 0 to 4095. A large discrepancy between AmpGain and RangeID would point to a hardware problem e.g.:

AmpGain/RangeID/DAC: 0/4/265.

4.3.2 Setting Software Parameters: Filter, Gas Factor, Tmp. Coeff.

There are three parameters that are under the control of the user and are accessible from the parameter selection box as shown below. These are:

- Digital filter—noise reduction
- Gas Factor—compensates for different background gases
- Temperature coefficient—corrects baseline drift due to temperature.

Select Factor to Adjust

Filter Gas Factor Tmp. Coeff.

Figure 4.2: Parameter Selection Box

4.3.2.1 THE DIGITAL FILTER

The Analyzer software performs a digital operation to reduce the noise from the BDS sensor and amplifier. This filtering is reduced to around 10 ppb. If the signal exceeds 10 ppb, the filter disengages in order to track the transient faster. The number approximately corresponds to the response time of the filter in minutes from 10 to 90 %. The range is from 1 to 60 minutes of the 90 % response time. Five minutes is the default.

4.3.2.2 The Gas Factor

The gas factor coefficient in the BDS 3960 is the ratio of the output of the sensor taken in a N₂ background over the output of the sensor in the new background gas. The output of the sensor depends on the mechanics of diffusion. Since the diffusion coefficient of oxygen depends on the viscosity of the background gas, according to the laws of diffusion, the output of the sensor becomes inversely proportional to the viscosity of the background gas.

The output of the sensor can be predicted by looking up the viscosity of the new background gas and compare it to the viscosity of N₂ at the same temperature. Using values obtained from the a science handbook, the following gas factor coefficients for the BDS sensors are calculated

Table 4-1: Gas Factor for Selected Gases

N₂ = 1*

H₂ = 1.99

He = 0.90

Ar = 0.79

*Output normalized by calibrating with a span gas in N₂.

The values in Table 4-1 are theoretical but should give a first approximation as to what the output of the sensor will be in the new background gas. The BDS 3960 will make further refinements once the proper gas factor is input.

The working range of adjustment is 0.25 to 2.50. This factor will divide the output. For example if the factor is set to 2.00, the output of the sensor, when read by the PPC application will be divided by two.

Special consideration on the working range: Changing the gas correction factor has an effect on the maximum working range of the analyzer, e.g.: if a gas factor of 2.00 is selected the maximum working range of the analyzer is 50 ppm. Any reading above this, may saturate the amplifier.

4.3.2.3 TEMPERATURE COEFFICIENT

The output of the sensor is affected by temperature. There are two types of temperature compensation on the BDS 3960. One is the compensation to high levels of oxygen, more than 100 ppb. This effect is transparent to the user and is handled by the software application on the PPC. It requires no input from the user. The second compensation involves the baseline drift due to temperature. This value is generally set at the factory but can be modified or adjusted by the user. Since the sensor is temperature controlled, the default is zero. The following discussion is just information on its possibilities.

The baseline drift temperature coefficient is a number with units of ppb/degree centigrade and must be matched to the sensor's characteristic drift over temperature. This coefficient ranges from 0.50 to 1.75 ppb/°C.

Note: The coefficient is different from sensor to sensor. If the sensor is replaced, a new coefficient must be entered. TAI can supply this coefficient or it may be determined by the user.

The coefficient can be adjusted between 0.00 and 5.00 using the Up and Down buttons on the instrument. To estimate it in the field:

1. Set the coefficient to zero.
2. Run the analyzer on "Zero" calibration gas for two weeks or until a baseline stability is reached, i.e. the oxygen reading does not fluctuate.



3. After the sensor has been purged for at least two weeks and the baseline is stable, monitor the oxygen reading and ambient temperature over a minimum period of 24 hours. Take the maximum and minimum oxygen readings, and the maximum and minimum temperature readings.
4. Calculate the coefficient using the relation:

$$\text{Coefficient} = (\text{O}_2 \text{ max} - \text{O}_2 \text{ min}) \div (\text{Temp max} - \text{Temp min})$$

For example:

In a 24 hour run:

$$\text{O}_2 \text{ max} = 3.55 \text{ ppb}$$

$$\text{O}_2 \text{ min} = 1.75 \text{ ppb}$$

$$\text{Temp max} = 24.5 \text{ degrees C.}$$

$$\text{Temp min} = 22.1 \text{ degrees C.}$$

$$\text{Coefficient} = (3.55-1.75)\text{ppb} \div (24.5-22.1) \text{ }^\circ\text{C} = 0.75 \text{ ppb}/^\circ\text{C}.$$

This value is currently set to zero, since the sensor is temperature controlled and should be left at zero unless qualified personnel give instructions to change it.

4.3.2.4 SET DEFAULTS

The *Set Defaults* button will reset all parameters in the software, such as calibration, alarm and range settings, Filter, Gas Factor, temperature coefficient, etc. to their factory default values. Some of the default values are listed below:

Table 4-2: Parameter Default Values

Parameter	Default Value
Zero Offset	0
Span Gas	8.00 PPM
SpanFactor	24.42 (Default span factor = 100000 ppb/ 4095 ADC counts)

Filter	5 minutes
Gas Factor	1.00
Temperature Coef.	0 ppb/degree centigrade
Alarm 1 setpoint	1000 ppb
Alarm 2 setpoint	100 ppb

Pressing the *Set Defaults* button brings up a confirmation dialog box. Press *Yes* to reset to the defaults or *No* to keep the current values.

4.4 Calibration of the Analyzer

The analyzer must be calibrated prior to use. For most applications where the desired range of measurement is 0 to 10 ppm, or less we recommend the analyzer be calibrated using a span gas with a concentration between 7.0 to 9.0 ppm oxygen in nitrogen. This will require that calibration be performed in the 0-10 ppm analyzer range.

Before the cell is ready for calibration, it must be purged with sample gas to a low oxygen level—preferably below 0.1 ppm. If the oxygen content of the sample gas is higher than 0.1 ppm, a zero gas such as nitrogen having an oxygen concentration below 0.1 ppm may be required.

4.4.1 Zero Cal

The BDS Sensor has a zero offset of less than 5 ppb oxygen. Normally, the offset slowly decreases during the first 7 to 10 days of operation, and is expected to reach a steady value after this time.

Generally, the value of the zero offset is part of the oxygen reading of the sample gas as shown by the analyzer readout. As an example, a reading of 5 ppb oxygen may include 0.4 ppm oxygen in the sample gas and a 5 ppb zero offset.

The determination of the zero offset requires the use of oxygen free gas to the analyzer. The BDS 3960 has an oxygen scrubber as an integral part of its sample system. The software and electronics automatically re-route the sample gas through the scrubber to provide the sensor with oxygen free gas. Best results as well as prolonged scrubber life is attained when the oxygen concentration of the sample gas is below 1 ppm oxygen.

A zero calibration is not recommended during the first 10 days of the operation of the cell.

The *ZERO* button on the Main screen is used to enter the zero calibration function. Zero calibration can be performed either automatically or manually.

In the automatic mode, an internal timer will purge sensor for five minutes before registering the zero offset of the sensor plus electronics. As the timer counts down, you can force the analyzer to accept the current zero offset using the *Accept* button. Pressing the *Accept* button anytime during the countdown period forces the analyzer to accept the zero offset calibration.

Pressing *Cancel* will return the analyzer back to the analyze mode without accepting the zero calibration. In this case, the previous zero calibration values will remain as the current values.

4.4.1.1 ZERO FAILURE

The analyzer checks the output of the cell at the end of the span. If the raw output of the cell produces an Analog to Digital converter count less than 4000 on amplifier gain 0, the zero will not be accepted. The analyzer will use the previous calibration values, and display at the top of the main screen:

ZERO-CALIBRATION

ERROR

4.4.2 Span Cal

The *SPAN* button on the main screen is used to span calibrate the analyzer. Span calibration can be performed automatically or manually. In the automatic mode, an internal timer will purge sensor for five minutes before taking in the zero offset of the sensor plus electronics. Again, the *ACCEPT* button can be pressed at anytime during the countdown period to accept the zero offset calibration.

Pressing the *CANCEL* button will return the analyzer to the analyze mode without accepting the zero calibration. The previous zero calibration will still be in effect.



4.4.2.1 SPAN FAILURE

The analyzer checks the output of the cell at the end of the span. If the raw output of the cell is less than 1.5 nA/ppb or more than 13.5 nA/ppb O₂, the span will not be accepted. The analyzer will return to the previous calibration values, and display at the top of the main screen:

SPAN-CALIBRATION

ERROR

4.5 The Alarms Function

The Model BDS 3960 is equipped with 2 fully adjustable concentration alarms and a system failure alarm. Each alarm has a relay with a set of form "C" contacts rated for 3 amperes resistive load at 250 VAC. See Figure 3-5 in Chapter 3, *Installation* and/or the Interconnection Diagram included at the back of this manual for relay terminal connections.

The system failure alarm has a fixed configuration as described in Chapter 3 *Installation*.

The concentration alarms can be configured from the PPC software as either *high* or *low* alarms by the operator. The alarm modes can be set as *latching* or *non-latching*, and either *failsafe* or *non-failsafe*, or, they can be *defeated* altogether. The setpoints for the alarms are also established using this function.

Depending on your process, you can choose to configure the alarms in a number of ways. Consider the following four points:

1. Which if any of the alarms are to be high alarms and which if any are to be low alarms?

Setting an alarm as HIGH triggers the alarm when the oxygen concentration rises above the setpoint. Setting an alarm as LOW triggers the alarm when the oxygen concentration falls below the setpoint.

Decide whether you want the alarms to be set as:

- Both high (high and high-high) alarms, or
- One high and one low alarm, or
- Both low (low and low-low) alarms.

2. Are either or both of the alarms to be configured as failsafe?

In failsafe mode, the alarm relay de-energizes in an alarm condition. For non-failsafe operation, the relay is energized in an alarm condition. You can set either or both of the concentration alarms to operate in failsafe or non-failsafe mode.

3. Are either of the alarms to be latching?

In latching mode, once the alarm or alarms trigger, they will remain in the alarm mode even if process conditions revert back to non-alarm conditions. This mode requires an alarm to be recognized before it can be reset. In the non-latching mode, the alarm status will terminate when process conditions revert to non-alarm conditions.

4. Are either of the alarms to be defeated?

The defeat alarm mode is incorporated into the alarm circuit so that maintenance can be performed under conditions which would normally activate the alarms.

The defeat function can also be used to reset a latched alarm. (See procedures, below.)

Each of the concentration alarms have their own button on Main display of the PPC application, ALARM 1 and ALARM 2. Once you press on the alarm buttons you will be presented with alarm setup screen.

Five parameters can be changed on the alarm setup screen:

1. Value of the alarm level—##### ppb (oxygen); value can be set from 0 to 100,000 ppb.
2. Out-of-range direction—High or Low
3. Latch control—Latching or Non-latching.
4. On/off Control—Active or Defeated.
5. Safety Mode—Failsafe or Non-failsafe.

To reset a latched alarm, go to On/off Control and select *defeated*.

4.6 The Range Function

The Range function allows the operator to program up to four concentration ranges to correlate with the DC analog outputs. If no ranges are defined by the user, the instrument defaults to:

- Range 1 = 0–100 ppb
- Range 2 = 0–1000 ppb
- Range 3 = 0–10000 ppb
- Range 4 = 0–100000 ppb

The Model BDS 3960 is set at the factory to default to autoranging. In this mode, the PPC application automatically responds to concentration changes by switching ranges for optimum readout sensitivity. If the current range limits are exceeded, the instrument will automatically shift to the next higher range. If the concentration falls to below 90% of full scale of the next lower range, the instrument will switch to that range. A corresponding shift in the DC percent-of-range output, and in the range ID outputs, will be noticed.

The autoranging feature can be overridden so that analog output stays on a fixed range regardless of the oxygen concentration detected. If the concentration exceeds the upper limit of the range, the DC output will saturate at 1 VDC (20 mA at the current output).

Even if the output is set to a fixed range, the digital readout of the concentration is unaffected by the fixed range. It continues to read accurately with full precision. See *Front Panel* description in Chapter 1.

The automatic fourth range is always 0-100000 ppb (100 ppm) and should not be adjusted.

4.6.1 Setting the Analog Output Ranges

To set the ranges, click on the list box on the main screen. The following options will pop down.

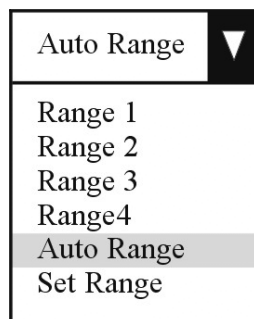
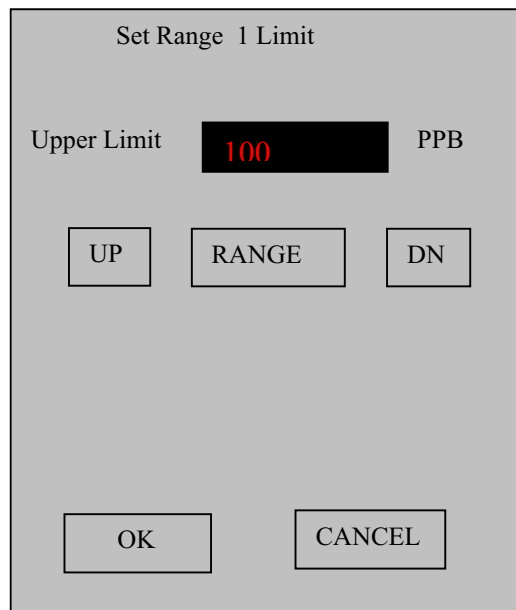


Figure 4.3: Range Options List Box

To Set the ranges to values different than the default, click on ‘Set Range’ and the Set Range screen will pop up.



Set Range 1 Limit

Upper Limit **100** PPB

UP RANGE DN

OK CANCEL

Figure 4.4: Range Setup Screen

The first screen allows you to set range 1. If you click on the *Range* button, it will take you to the setup of range 2. Click *Range* again will take you to the setup of range 3, then range 4, then back again to range 1. Note that ranges and alarms are set in ppb units.

Note: The ranges must sequentially increase from low to high, for example, if range 1 is set as 0–100 ppb and range 2 is set

as 0–1000 ppb, range 3 cannot be set as 0– 500 ppb since it is lower than range 2.

Note: Refer to Section 4.3.2.2 to find maximum working range.

4.6.2 Fixed Range Analysis

The autoranging mode of the instrument can be overridden, forcing the analyzer DC outputs to stay in a single predetermined range.

To switch from autoranging to fixed range analysis, click on the list box of the main screen, as shown on figure 4.3, then select on the range of interest.

4.8 Signal Output

The standard Model BDS 3960 Oxygen Analyzer is equipped with two 0–1 VDC analog output terminals (one concentration and one range ID), and two isolated 4–20 mA DC current outputs (one concentration and one range ID) accessible from the 50-pin equipment interface connector located on the back panel.

See *Rear Panel* in Chapter 3, *Installation*, for illustration and pin configuration of the interface connector.

The signal output for concentration is linear over the currently selected analysis range. For example, if the analyzer is set on a range that was defined as 0–100 ppb O₂, then the output would be as shown in Table 4-2.

Table 4-2: Linear Output for a 0-100 ppm O₂ Range

ppb O ₂	Voltage Signal Output (VDC)	Current Signal Output (mA DC)
0	0.0	4.0
10	0.1	5.6
20	0.2	7.2
30	0.3	8.8
40	0.4	10.4
50	0.5	12.0

60	0.6	13.6
70	0.7	15.2
80	0.8	16.8
90	0.9	18.4
100	1.0	20.0

The analog output signal has a voltage which depends on the oxygen concentration AND the currently activated analysis range. To relate the signal output to the actual concentration, it is necessary to know what range the instrument is currently on, especially when the analyzer is in the autoranging mode.

To provide an indication of the range, a second pair of analog output terminals are used. They generate a steady preset voltage (or current when using the current outputs) to represent a particular range. Table 4-3 gives the range ID output for each analysis range.

Table 4-3: Range ID Output

Range	Voltage (V)	Current (mA)
Range 1	0.25	8
Range 2	0.50	12
Range 3	0.75	16
Range 4	1.00	20

4.9 Switching The Program Back To The Front

There are times that the Analyzer program may drop out of sight from the front of the screen even though it is still running. If Analyzer program icon is tapped to run the program, an error message will be

displayed. This is because windows CE® does not allow two instances of the same program.

If this occurs, tap on the blue the corner of the blue bar (blue bar appears either at the top of the screen or at the bottom, depending on which application is at the front), next to the windows logo, to bring up the pop up menu.

- Tap on Settings
- On the Settings form, tap on the System tab
- Tap on the Memory icon
- Tap on the Running Programs tab
- Tap of “TET-AI PPB OXYGEN ANALYER” on the program lists to select the Analyzer program
- Tap the Activate button. Now the Analyzer program should be at the front.



Maintenance

5.1 Routine Maintenance

Aside from normal cleaning and checking for leaks at the gas connections, routine maintenance is limited to refilling sensor with deionized water, replace burned fuses, replace backup batteries for PPC, and recalibration. For recalibration, see Section 4.4 *Calibration*.

WARNING: SEE WARNINGS ON THE TITLE PAGE OF THIS MANUAL.



5.2 Adding Water to the BDS Sensor

When running dry gas through the sensor, water is extracted from the electrolyte. Therefore, the electrolyte level should be checked periodically. When the electrolyte level is low, only de-ionized water or distilled water should be added into the sensor. It typically takes about four months to dry the electrolyte from the MAX line to the MIN line when the sensor is operated on a bone dry gas line.

It is not necessary to turn off the power to the analyzer while adding water, but care should be taken that no water is splashed outside the sensor. Spilling water on the PC board could cause serious damage to the analyzer and electric shock to the personal.

Unscrew and take the sensor cap off. Use the wash bottle provided to squeeze de-ionized water into the sensor, as shown in Figure 5.1. It is a good practice that water is added before reaching the MIN line. Reinstall the cap after adding water.

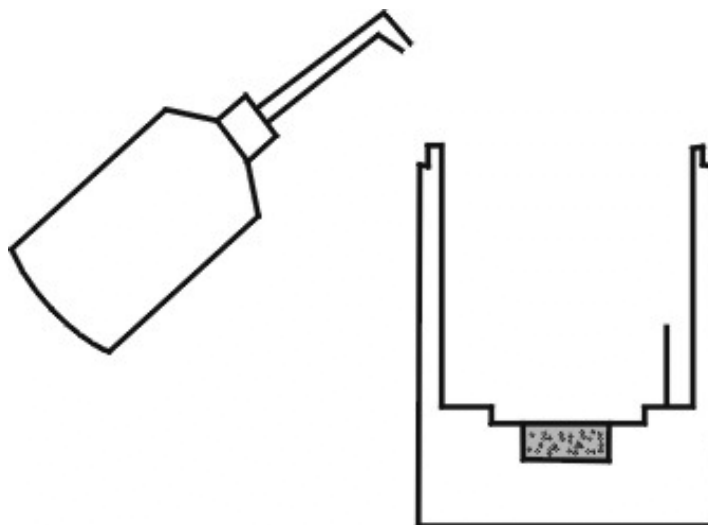


Figure 5.1 Adding Water into the BDS sensor

WARNING:



THE SENSOR USED IN THE MODEL BDS 3960 OXYGEN ANALYZER USES ELECTROLYTE WHICH CONTAINS POTASSIUM HYDROXIDE, THAT CAN BE HARMFUL IF TOUCHED, SWALLOWED, OR INHALED. AVOID CONTACT WITH ANY FLUID OR POWDER IN OR AROUND THE UNIT. WHAT MAY APPEAR TO BE PLAIN WATER COULD BE THE ELECTROLYTE. IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. CALL PHYSICIAN. (SEE APPENDIX, MATERIAL SAFETY DATA SHEET.)

5.3 Fuse Replacement

1. Place small screwdriver in notch, and pry cover off, as shown in Figure 5-2. Remove fuse holder.
2. Replace fuses. Use 2A 250 VAC 5x20 mm slow-blow. Install one at each side of fuse holder

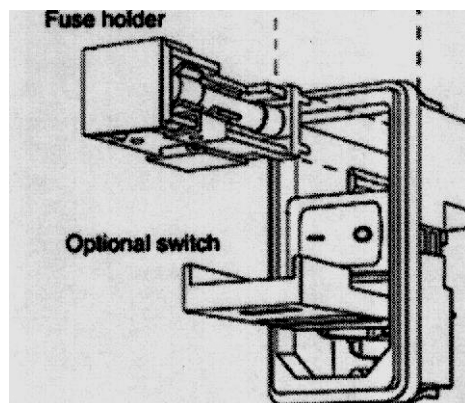


Figure 5-2: Removing Fuse Block from Housing

5.4 Battery Backup Replacement

The software application running on the PPC is maintained when power is removed from the analyzer by a single 3 volt lithium battery. If the unit is powered down and the battery power is low, you run the risk of losing the program. To prevent this from happening, replace the backup battery as often as six months. Use a CR2032 or DL2032 for replacement.

Note: Make sure that the main battery of the PPC is charged when you change the backup battery or you will lose the software application. If the software application is lost for any reason, use the installation floppy disk as instructed in section 5.5.

1. Power Analyzer down.
2. Loosen the thumb screws of the front panel and slide the drawer assembly out.
3. Remove the two screws on the back of the front panel that hold the PPC in place, then remove the PPC.
4. Slide the switch on the back of the PPC to Backup. Open the battery compartment and remove the old battery.
5. Install a new battery. Make sure that the '+' side is on top facing out.
6. Replace the battery cover and move the switch to lock position.

5.5 Reinstalling Application software to PPC.

If the applications software on the PPC becomes corrupt or is lost, it can be restored by Downloading the Analyzer program and components. Before installing the software, you must have a software version of ActiveSync® on a separate PC computer running Windows 95 or later operating system as well as a serial communication cable or cradle **TAI P/N CP2237**. ActiveSync® is a property of Microsoft Corp. and can be downloaded from their website. The Analyzer program and its components can be send via email upon request. Please have serial number of analyzer, it will be requested.

1. Connect the PPC to the serial communication cable or cradle.
2. Launch ActiveSync.
3. Open ActiveSync Explorer
4. Insert the backup floppy in the disk drive of the PC computer and open the Windows Explorer.
5. Locate the file *vbceutil.dll* and copy it to the windows directory of the PPC, file size is 77Kb
6. Similarly, copy *regsvrce program* for the PPC 300 to the windows directory on the PPC, file size is 7.50kb (this is the version for target\mips).
7. Run *CDI\setup.exe* to install the analyzer program
8. Move *Teledyne_log.bmp* to \Analyzer directory on the PPC.
9. Register *vbceutil.dll* on the PPC as follows:
 - Click start_Programs_explorer
 - Click show_My Device
 - Double click on the windows folder
 - Find *regsvrce program* and double click to run;
 - Type path:
c:\windows\vbceutil.dll
then press OK button
 - Double click on *regsvrce program* icon to get the message that the registration was successful. If it was not successful, repeat the last two steps.

10. Disconnect the serial cable and run the Analyzer program from the Start pull down menu to check for successful installation.

5.5 Major Internal Components

The Sensor is accessed by loosening the thumbscrew on the front panel and sliding it out, as described earlier. Other internal components can be accessed the same way. The gas piping is illustrated in Figure 2-3, and the major electronic component locations are described in Chapter 2.

WARNING: *SEE WARNINGS ON THE TITLE PAGE OF THIS MANUAL.*



The BDS 3960 contains the following major components:

- Analysis Section
 - Sensor with stainless steel wetted parts
 - Sample system
- Power Supply PCB
- Microprocessor base I/O board with amplifier daughter board
- LED display PCB
- Palm Portable Computer with Windows CE

See the drawings in the Drawings section in back of this manual for details.

5.6 Cleaning

If the instrument is unmounted at time of cleaning, disconnect the instrument from the power source. Close the front-panel access drawer. Clean outside surfaces with a soft cloth dampened slightly with plain clean water. Do not use any harsh solvents such as paint thinner or benzene.

DO NOT wipe front panel while the instrument is controlling your process.

5.7 Troubleshooting

Symptoms

Possible causes and Solutions

Read higher than expected	(1), (2), (3)
Read lower than expected	(2), (3)
Read negative	(3), (4)
Noise signal	(3), (5)
Slow response	(5)

Causes and solution keys:

- (1) **Gas leak:** Make sure to use new VCR gaskets, high quality valves and gas regulator for the sampling system. Tighten each connection.
- (2) **Improper gas flow rate:** adjust the inlet pressure to obtain 0.5 – 1 SLPM flow rate.
- (3) **Improper calibration of the analyzer:** Press the *SYSTEM* button on Main menu screen of the PPC to bring the System screen. Then press the “Set default” button. This will return the analyzer to its defaults settings in calibration and zero values. Recalibrate the analyzer with a high quality standard gas if it is necessary. Be warned this will set defaults to ranges and alarms settings as well.
- (4) **Just after adding water:** The analyzer will recover by itself.
- (5) **Gas entered and is trapped in the sensor:** This could happen if the sensor is filled with the electrolyte improperly, or the sensor is pressurized because of a clogged vent. To remedy this situation, uninstall the sensor and take off the cap carefully, then apply a vacuum degas process as shown in the Figure 5-4. Degassing in a 28 inch mercury vacuum for 5 minutes is sufficient to remove the gas bubbles. Reinstall the sensor into the analyzer.

Note: A low cost vacuum degas kit (TAI P/N B72098) is available from Teledyne Analytical Instruments.

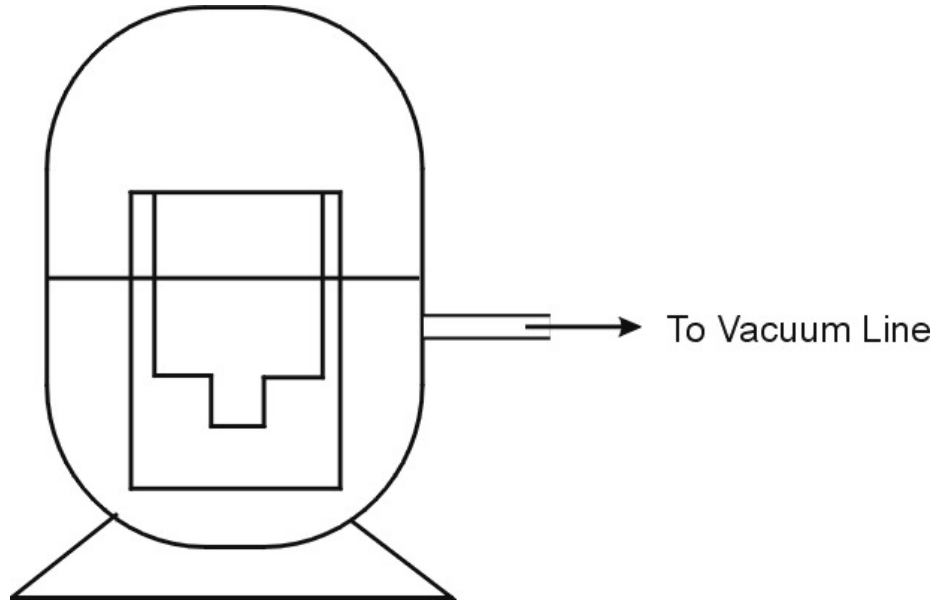


Figure 5-3: Vacuum Degassing for the BDS Oxygen Sensor

Appendix

A-1 Specifications

Packaging: General Purpose

- Flush panel mount (Standard).

Sensor: Teledyne BDS Sensor, patent pending.

Sample System: All wetted parts of 316 stainless steel with built-in in pressure regulator, oxygen scrubber and calibration valves.

90 % Response Time: Less than 90 seconds at 25 °C (77 °F) on 10, and 100 ppm range. 90 seconds on 1000ppb range.

Software programmable response in 100 ppb range from 1 minute to 60 minutes. Default is 5 minutes response time.

Ranges: Three user definable ranges from 0–100 ppb to 0–100 ppm, plus over range of 0-100 ppm.

Autoranging with range ID output.

Alarms: One system-failure alarm contact to detect power failure or sensor-zero and span failure.

Two adjustable concentration threshold alarm contacts with fully programmable setpoints.

Displays: 5 digit LED display and Backlit LCD display from PPC

Power: Universal power supply 100-125 VAC, at 50/60 Hz. 200-240 VAC optional



Operating Temperature: 5-40 °C

Accuracy: ±2% of full scale for all ranges at constant temperature.

All accuracy specifications are contingent upon the completion of zero and span calibration.

All accuracy is established at constant pressure and equilibrium has been established.

Analog outputs: 0-1 VDC percent-of-range,
0-1 VDC range ID.
4-20 mA DC (isolated) percent-of-range,
4-20 mA DC (isolated) range ID.

Dimensions: 19 cm high, 24.9 cm wide, 31 cm deep
(6.96 in high, 8.7 in wide, 12.1 in deep).

A-2 Recommended 2-Year Spare Parts List

Qty.	Part Number	Description
1	C65507B	Back Panel Board
1	C72914A	Front Panel Board
1	C72000A	Preamplifier Board (Instruction)
1	B71997A	Main Computer Board
2	F1296	Fuse, 2A, 250V 5x20mm (European) Slow Blow
1	CP1798	50 pin D-sub interface connector
50	CP1799	Pins for CP1798 connector
1	B597	125ml wash bottle for DI water
1	B598	125ml electrolyte bottle
1	P1076	Pipet
1	B72098	BDS sensor recovery kit
1	CP2237	PDA cradle
1	C58750	Oxygen Scrubber

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

Orders should be sent to:

TELEDYNE Analytical Instruments

16830 Chestnut Street
City of Industry, CA 91749-1580

Phone (626) 934-1500, Fax (626) 961-2538

Web: www.teledyne-ai.com
or your local representative.

A-3 Drawing List

D-73299 Outline Diagram

A-4 19-inch Relay Rack Panel Mount

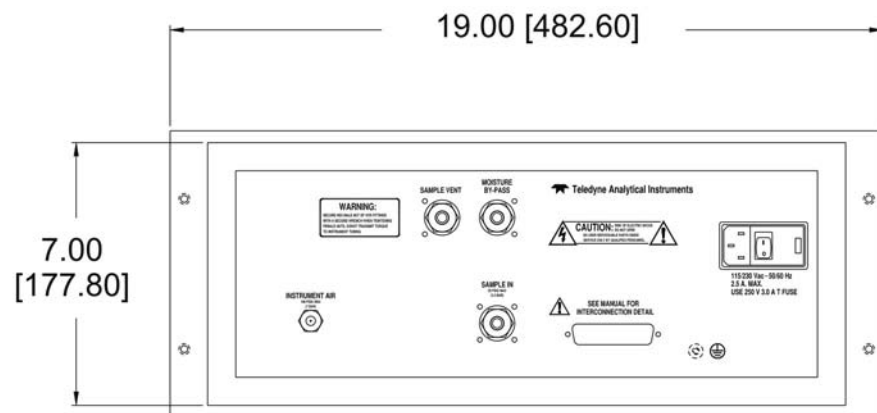


Figure A-1: Single 19" Rack Mount (dimensions in mm)

A-5 Application notes

Pressure and flow recommendations:

3960 series analyzers require reasonably regulated sample pressures. While the 3960 analyzers are not sensitive to variations of incoming pressure (provided they are properly vented to atmospheric pressure), the pressure must be maintained so as to provide a useable flow rate through the analyzer. Any line attached to sample vent should be 1/4" or larger in diameter.

Flow rate recommendations:

A usable flow rate for a 3960 series analyzer is one which can be measured on the flowmeter. This is basically 0.5 - 1.0 SLPM. The optimum flow rate is 1 SLPM (mid scale). Note: response time is dependent on flow rate, a low flow rate will result in slow response to O₂ changes in the sample stream. The span flow rate should be the approximately same as the sample flow rate.

Cell pressure concerns:

The sensors used in 3960 series analyzers are optimized to function at atmospheric pressure.

Bypass:

To improve the system response, a bypass can be added to increase the sample flow rate to the analyzer by a factor of ten. A bypass provides a sample flow path around the analyzer of 2 - 18 SCFH, typically.

Conversions:

1 PSI = 2.04 INCHES OF MERCURY (in. Hg.)

1 SCFH = 0.476 SLPM

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

Material Safety Data Sheet

Section I - Product Identification

Product Name: Micro-fuel Cells
 Mini-Micro-fuel Cells
 Super Cell, all classes except T-5F
 Electrochemical Oxygen Sensors, all classes

Manufacturer: Teledyne Electronic Technologies
 Analytical Instruments

Address: 16380 Chestnut Street,
 City of Industry, CA 91749

Phone: (626) 961-9221

Technical Support: (626) 934-1673

Environment, Health and Safety: (626) 934-1592

Date Prepared: 11/23/98

Section II - Physical and Chemical Data

Chemical and Common Names:	Potassium Hydroxide (KOH), 15% (w/v) Lead (Pb), pure	
CAS Number:	KOH 1310-58-3 Pb 7439-92-1	
	KOH (15% w/v)	Pb (pure)
Melting Point/Range:	-10 to 0 °C	328 °C
Boiling Point/Range:	100 to 115 °C	1744 °C
Specific Gravity:	1.09 @ 20 °C	11.34
pH:	>14	N/A
Solubility in Water:	Completely soluble	Insoluble
Percent Volatiles by Vol.:	None	N/A
Appearance and Odor:	Colorless, odorless solution	Grey metal, odorless



Section III -Physical Hazards

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

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

Section IV - Health Hazard Data

Primary route of entry: Ingestion, eye/skin contact

Exposure limits: OSHA PEL: 0.05 mg./cu.m. (Pb)
ACGIH TLV: 2 mg/ cu.m. (KOH)

Effects of overexposure

Ingestion: The electrolyte could be harmful or fatal if swallowed.
Oral LD50 (RAT) = 3650 mg/kg

Eye: The electrolyte is corrosive; eye contact could result in permanent loss of vision.

Dermal: The electrolyte is corrosive; skin contact could result in a chemical burn.

Inhalation: Liquid inhalation is unlikely.

Signs/symptoms of exposure: Contact with skin or eyes will cause a burning sensation and/or feel soapy or slippery to touch.

Medical conditions

aggravated by exposure: None

Carcinogenicity: NTP Annual Report on Carcinogens: Not listed
LARC Monographs: Not listed
OSHA: Not listed

Other health hazards: Lead is listed as a chemical known to the State of California to cause birth defects or other reproductive harm.

Section V - Emergency and First Aid Procedures

Eye Contact: Flush eyes with water for at least 15 minutes and get immediate medical attention.

Skin Contact: Wash affected area with plenty of water and remove contaminated clothing. If burning persists, seek medical attention.

Ingestion: Give plenty of cold water. Do not induce vomiting. Seek medical attention. Do not administer liquids to an unconscious person.

Inhalation: Liquid inhalation is unlikely.

Section VI - Handling Information

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

Protective clothing: Rubber gloves, chemical splash goggles.

Clean-up procedures: Wipe down the area several times with a wet paper towel. Use a fresh towel each time.

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

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

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

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