Aqueous Ozone Monitor

2B *Technologies, Inc*.

OPERATION MANUAL

Model UV-106-W

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IDENTIFICATION RECORDS

Record the following information for future reference:

Unit serial number: ______________________________________

Warranty start date: _______________________________________
(date of receipt)

PRINTING HISTORY

New editions are complete revisions of the manual and incorporate all previous update pages and write-in instructions. This manual will be revised as necessary. Revisions can be in the form of new editions, update pages, or write-in instructions.

Revision A .... June 2014

TRADEMARKS AND PATENTS

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WARRANTY STATEMENT

2B Technologies, Inc. warrants its products against defects in materials and workmanship. 2B Technologies will, at its option, repair or replace products which prove to be defective. The warranty set forth is exclusive, and no other warranty, whether written or oral, is expressed or implied. 2B Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Warranty Periods

The warranty period is one (1) year from date of receipt by the purchaser, but in no event more than thirteen (13) months from original invoice date from 2B Technologies, Inc.

Warranty Service

Warranty Service is provided to customers via web ticket, email and phone support, Monday - Friday, from 9:00 a.m. to 5:00 p.m., Mountain Time USA. The preferred method of contacting us is through our web ticketing software at:

www.twobtech.com/techsupport

This way all technical staff at 2B Tech will be alerted of your problem and be able to respond. When you receive an email reply, please click on the Ticket link provided to continue to communicate with us directly over the internet. The web ticket approach to customer service allows us to better track your problem and be certain that you get a timely response. We at 2B Tech pride ourselves on the excellent customer service we provide.

You may also contact us by email at techsupport@twobtech.com or by phone at +1(303)273-0559. In either case, a web ticket will be created, and future communications with you will be through that ticket.

Initial support involves trouble-shooting and determination of parts to be shipped from 2B Technologies to the customer in order to return the product to operation within stated specifications. If such support is not efficient and effective, the product may be returned to 2B Technologies for repair or replacement. Prior to returning the product, a Repair Authorization Number (RA) must be obtained from the 2B Technologies Service Department. We will provide you with a simple Repair Authorization Form to fill out to return with the instrument. You also may download this form at http://twobtech.com/RMA.pdf.

Shipping

2B Technologies will pay freight charges for replacement or repaired products shipped to the customer site. Customers shall pay freight charges for all products returning to 2B Technologies.

Conditions

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance, adjustment, calibration or operation by customer. Maintenance, adjustment, calibration or operation must be performed in accordance with instructions stated in this manual. Usage of maintenance materials purchased from suppliers other than 2B Technologies will void this warranty.

Limitation of Remedies and Liability

The remedies provided herein are the Customer's sole and exclusive remedies. In no event shall 2B Technologies be liable for direct, indirect, special, incidental or consequential damages (including loss of profits) whether based on contract, tort or any other legal theory. The Ozone Monitor manual is believed to be accurate at the time of publication and no responsibility is taken for any errors that may be present. In no event shall 2B Technologies be liable for incidental or consequential damages in connection with or arising from the use of the Ozone Monitor manual and its accompanying related materials. Warranty is valid only for the country designated on the 2B Technologies quote or invoice.

WARNINGS

ENGLISH

⚠ ***WARNING:***
Any operation requiring access to the inside of the equipment, could result in injury. To avoid potentially dangerous shock, disconnect from power supply before opening the equipment.

WARNING:
This symbol, ⚠ on the instrument indicates that the user should refer to the manual for operating instructions.

WARNING:
If this instrument is used in a manner not specified by 2B Technologies, Inc. USA, the protection provided by the instrument may be impaired.

ESPAÑOL

⚠ ***ATENCION:***
Cualquier operación que requiera acceso al interior del equipo, puede causar una lesión. Para evitar peligros potenciales, desconectarlo de la alimentación a red antes de abrir el equipo.

ATENCION:
Este símbolo, ⚠ en el instrumento indica que el usuario debería referirse al manual para instrucciones de funcionamiento.

ATENCION:
Si este instrumento se usa de una forma no especificada por 2B Technologies, Inc., USA, puede desactivarse la protección suministrada por el instrumento.

FRANÇAIS

⚠ ***ATTENTION:***
Chaque opération à l'intérieur de l'appareil, peut causer du préjudice. Afin d'éviter un shock qui pourrait être dangereux, disconnectez l'appareil du réseau avant de l'ouvrir.

ATTENTION:
Le symbol, ⚠ indique que l'utilisateur doit consulter le manuel d'instructions.

ATTENTION:
Si l'instrument n'est pas utilisé suivant les instructions de 2B Technologies, Inc., USA, les dispositions de sécurité de l'appareil ne sont plus valables.

DEUTSCH

⚠ ***WARNHINWEIS:***
Vor dem Öffnen des Gerätes Netzstecker ziehen!

WARNHINWEIS:
Dieses, ⚠ auf dem Gerät weist darauf hin, dab der Anwender zuerst das entsprechende Kapitel in der Bedienungsanleitung lesen sollte.

WARNHINWEIS:
Wenn das Gerät nicht wie durch die Firma 2B Technologies, Inc., USA, vorgeschrieben und im Handbuch beschrieben betrieben wird, können die im Gerät eingebauten Schutzvorrichtungen beeinträchtigt werden.

ITALIANO

⚠ ***ATTENZIONE:***
Qualsiasi intervento debba essere effettuato sullo strumento può essere potenzialmente pericoloso a causa della corrente elettrica.
Il cavo di alimentazione deve essere staccato dallo strumento prima della sua apertura.

ATTENZIONE:
Il simbolo, ⚠ sullo strumento avverte l'utilizzatore di consultare il Manuale di Istruzioni alla sezione specifica.

ATTENZIONE:
Se questo strumento viene utilizzato in maniera non conforme alle specifiche di 2B Technologies, Inc. USA, le protezioni di cui esso è dotato potrebbero essere alterate.

DUTCH

⚠ ***OPGELET:***
Iedere handeling binnenin het toestel kan beschadiging veroorzaken. Om iedere mogelijk gevaarlijke shock te vermijden moet de aansluiting met het net verbroken worden, vóór het openen van het toestel.

OPGELET:
Het symbool, ⚠ geeft aan dat de gebruiker de instructies in de handleiding moet raadplegen.

OPGELET:
Indien het toestel niet gebruikt wordt volgens de richtlijnen van 2B Technologies, Inc., USA gelden de veiligheidsvoorzieningen niet meer.

1. *AQUEOUS OZONE MONITOR INTRODUCTION*

The Model UV-106-L Aqueous Ozone Monitor™ uses our patent-pending MicroSparge™ technology to measure dissolved ozone in water with high precision and accuracy. Unlike most dissolved ozone sensors, the instrument does not make use of a membrane that will foul over time. Instead, dissolved ozone is measured by nearly complete sparging of ~2 mL of water with ozone-scrubbed ambient air and integrating the gas-phase concentration of ozone stripped from solution. A small correction, based on the temporal profile of ozone removed from solution, is made to account for any ozone remaining in solution. Because ozone is measured in the gas phase, interferences from particles and other dissolved inorganic and organic compounds is removed, making the instrument applicable to both ultra pure water and "dirty" water, such as drinking water, which can contain a wide variety of dissolved inorganic and organic impurities and suspended particles.

1.1. Theory of Operation

Absorption of UV light has long been used for measurements of gas-phase ozone and of ozone dissolved in pure solvents with high precision and accuracy. The ozone molecule has an absorption maximum at 254 nm, coincident with the principal emission wavelength of a low-pressure mercury lamp. Fortunately, few molecules found at significant concentrations in the atmosphere absorb at this wavelength, making UV absorbance the most accurate method for measuring ozone in ambient air and in the output streams of ozone generators. There are commercial instruments available for the direct measurement of ozone in ultra high purity water and other solvents, but those instruments cannot be used for drinking water and other "dirty" water because of the presence of UV-absorbing compounds and particles that absorb and scatter UV radiation as well. In addition, the concentrations of those species change upon exposure to ozone, further complicating direct UV absorbance measurements of dissolved ozone.

Sparging (bubbling) of ozone from solution followed by measurement of ozone in the gas phase has the advantage of measuring the ozone in the absence of UV-absorbing interferences that remain in the water. However, instruments designed around this principle in the past have incorporated very large and cumbersome sparging chambers and rely on a fixed value of the Henry's Law constant, which is strongly temperature dependent, that partitions ozone between the liquid and gas phases.

In our patent-pending MicroSparge™ technology, the total quantity of ozone in a small volume of ~2 mL is sparged from solution over a period of ~5 s using ozone-scrubbed ambient air, and the ozone concentration vs time profile is measured in the gas phase. During the sparging period nearly all of the ozone is removed from solution. Integration under the ozone-time profile provides the total number of molecules of ozone in the ~2 mL sample. A small correction is made for the ozone that remains in solution based on the measured rate of exponential decay in the tail of the ozone-time profile.

Figure 1 is a schematic diagram of the Aqueous Ozone Monitor. Four 2-way valves and one 1-way valve direct the flow of air and water through the apparatus. The process of measuring dissolved ozone consists of two steps. In the first step (left panel of Fig. 2), the sample loop is overfilled with a flow of pressurized water from the water source to be analyzed, and an internal air pump pressurizes the impinger to empty ozone-depleted water from the previous sample. In the second step, valve states are changed so that air from the air pump both forces the ~2 mL water sample into the Impinger and sparges the sample, with the ozone-enriched air passing through the optical bench where ozone is measured. Each step requires approximately 5 seconds, and a new ozone measurement is reported every 10 seconds.

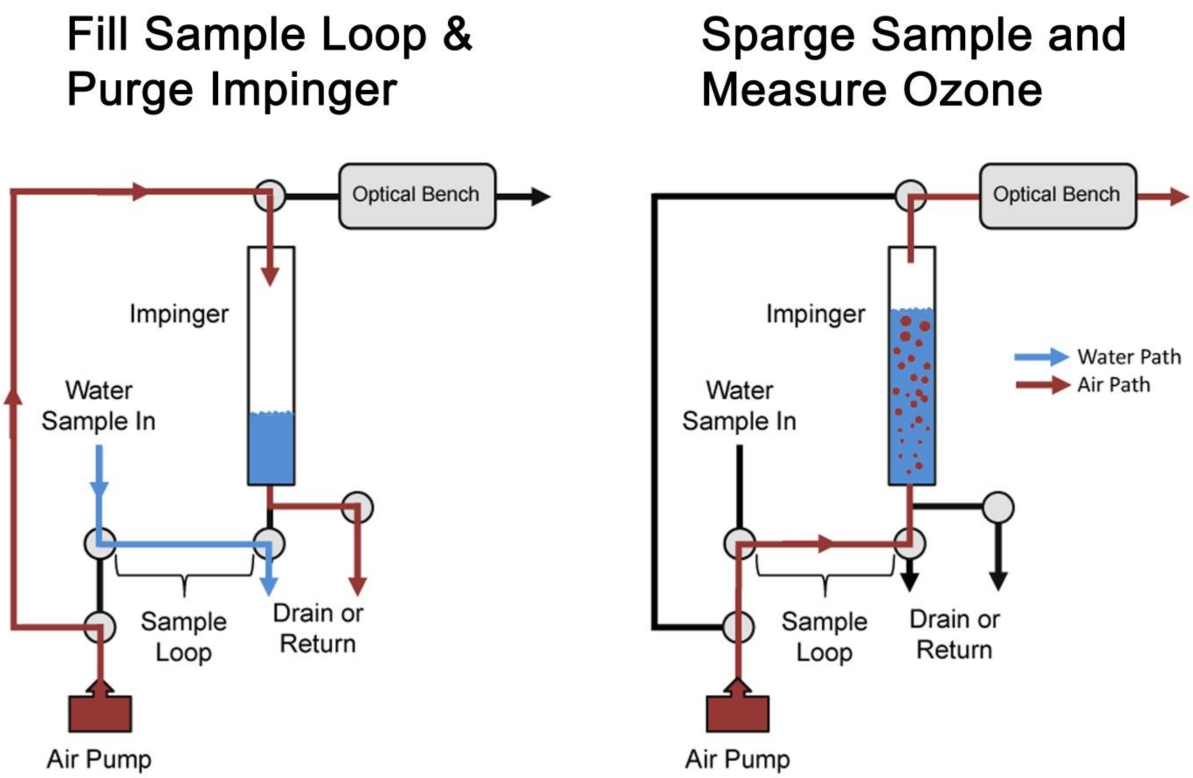

Figure 1.1. Schematic diagram of the air and water flow paths in the Aqueous Ozone Monitor.

The optical bench is identical to that of our Model 106-L Ozone Monitor. Ozone is measured based on the attenuation of UV light passing through a 14-cm absorption cell fitted with quartz windows. A low-pressure mercury lamp is located on one side of the absorption cell, and a photodiode is located on the opposite side of the absorption cell. The photodiode has a built-in interference filter centered on 254 nm, the principal wavelength of light emitted by the mercury lamp. Light intensity is continuously measured at a rate of 20 Hz, i.e., once every 0.05 seconds. At the beginning of the

Sparge cycle (right panel of Fig. 1.1), ozone-free air remaining from the Fill and Purge cycle (left panel of Fig. 1.1) passes through the absorption cell, and the light intensity in the absence of ozone (I_o) is obtained as an average of 3 data points. The light intensity then begins to fall as ozone sparged from the solution begins to pass through the detection cell.

More than 100 measurements of the light intensity (I) are made over the period of ~5 seconds required to remove >80% of the ozone from solution, and the concentration of ozone molecules is calculated for each measurement to create an ozone concentration vs. time profile using the Beer-Lambert Law,

$$C_{O_3}(molec/cm^3) = 10^9 \frac{1}{\sigma l} \ln\left(\frac{I_o}{I}\right) \quad (1)$$

where l is the path length (14 cm) and σ is the absorption cross section for ozone at 254 nm (1.15 x 10^{-17} cm^2 $molecule^{-1}$ or 308 atm^{-1} cm^{-1}).

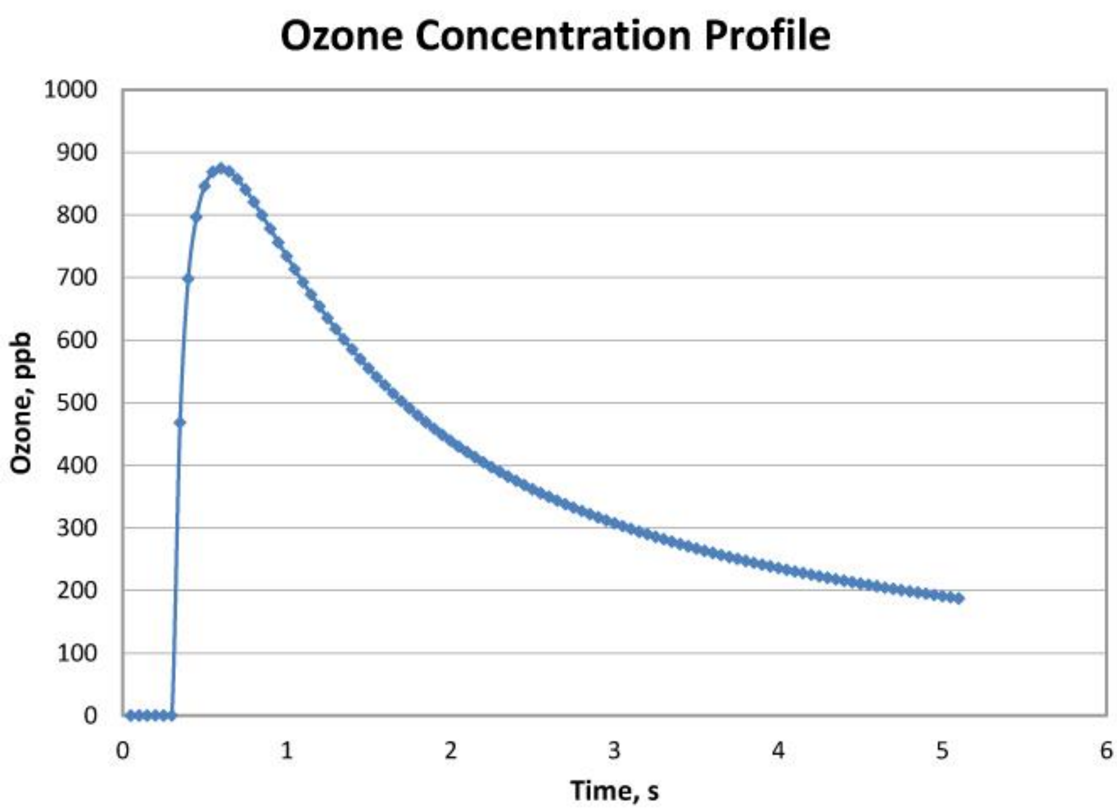

Figure 1.2. Ozone concentration vs. time profile for sparging of 2 mL of water with air. For convenience the ozone units are converted to a gas-phase mixing ratio in parts-per-billion.

We can obtain the total number of ozone molecules in the original ~2 mL sample of water by integrating under the ozone profile curve and multiply by the volumetric flow rate, F(cm^3/s),

$$N_{O_3} = F\int_0^{\infty t} C_{O_3}\,dt$$

but we can only measure ozone out to some finite time t, which is about 5 s, so we can separate the integral into two parts,

$$N_{O_3} = F\int_0^{t} C_{O_3}\,dt + F\int_t^{\infty} C_{O_3}\,dt$$

or

$$N_{O_3} = N_{O_3}(profile) + N_{O_3}(tail)$$

Here, the integral is separated into two terms. The first term is the integral under the measured profile of Fig. 1.2 out to a time t of ~5 s. In theory it takes an infinite time to purge all of the ozone from solution; thus the second term is calculated based on exponential removal of ozone from solution. The exponential decay constant, k, is calculated from a fit to the last one second of measured data, and the second term, or "tail" of the ozone profile is calculated as,

$$N_{O_3}(tail) = F(C_{O_3})_t \int_0^{\infty} e^{-kt}dt = \frac{F}{k}(C_{O_3})_t$$

where $(C_{O_3})_t$ is the concentration of ozone at time t (end of measurement period) and k is the exponential decay constant (units of s^{-1}) for removal of ozone from solution. The total number of molecules of ozone in the sparged sample is given by the sum of ozone molecules measured under the ozone profile and ozone molecules calculated to be in the tail of the decay curve. Once we know the total number of molecules in the sample loop volume V, we can calculate the dissolved ozone concentration,

$$C_{O_3,aqueous}(ppm) = \frac{N_{O_3}(total)}{N_A}\frac{48}{V\,\rho_{H_2O}}\ x\ 10^6$$

where NA is Avagadro's number (6.022 x 10^{23} molec/mol), 48 is the molecular weight of ozone in g/mol, V is the volume of the sample loop in mL (~2 mL), and ρ_{H_2O} is the density of water (1 g/mL).

Note that dissolved ozone is expressed on a weight-weight basis and that:

1 ppm = 1 μg/mL = 1 mg/L = 1 g/m^3

1 ppm = 1000 ppb

In principle, this measurement of ozone is absolute and requires no external calibration. However, non-linearity of the photodiode response and electronics and other factors can result in a small measurement error of up to a few percent. Therefore, each instrument is calibrated against a reference dissolved ozone monitor that itself has been calibrated against a NIST-traceable standard, thus providing an offset and slope (gain or sensitivity). The corrections for offset and slope are recorded in the instrument Birth Certificate. These calibration parameters are entered into the microprocessor of the instrument prior to shipment. The user may change the calibration parameters from the front panel if desired. It is recommended that the instrument be recalibrated at least once every year and preferably more frequently. The offset may drift due to temperature change or chemical contamination of the absorption cell. As discussed below, an accurate offset correction can be measured from time to time by sampling ozone-free water.

1.2. Specifications

Measurement Principle (Absolute Method)	Integrated UV Absorbance of Ozone Completely Sparged from ~2 mL of Water Sample
Applications	Ozone in Clean or "Dirty" Water
Ozone Concentration Range	0-100 ppm (g/m^3, µg/mL)
Precision	Greater of 0.05 ppm or 1% of Reading
Accuracy	Greater of 0.05 ppm or 1% of Reading
Zero Drift	< 0.05 ppm per month
Measurement Frequency	10 s
Response Time	20 s
Averaging Times	10 s, 1 min, 5 min, 1 hr
Ozone Units Displayed	ppm, µg/mL, mg/L, g/m^3
Power Requirements	11-14 V DC, 2.2 A at 12 V, 26.4 Watts
Average Sample Water Flow Rate	12 cc/min
Pressure Range	0-50 psi (>100 psi Burst Pressure)
Housing	NEMA
Relays (2 in Optional Breakout Box)	0.1 ppm Resolution, 2-Level, SPDT Dry Contacts
Analog Outputs	0-4 mA, 0-10 V (2 point scalable)
Digital Outputs	LCD, RS232, USB
Logging	Internal Data Logger, 16,368 lines (10 s avg. = 1.9 days; 5 min avg = 57 days)
LED Alarms	Low Lamp, Low Flow, Invalid Measurement
Dimensions	13.3 x 12.0 x 7.3 in (33.8 x 30.5 x 18.5 cm)
Weight	14.5 lb (6.6 kg)

2. OPERATION

Please read all the following information before attempting to install the Ozone Monitor. For assistance, please call 2B Technologies at (303)273-0559.

NOTE:

Save the shipping carton and packing materials that came with the Dissolved Ozone Monitor. If the Ozone Monitor must be returned to the factory, pack it in the original carton. Any repairs as a result of damage incurred during shipping will be charged.

2.1. Shipping Box Contents

Open the shipping box and verify that it contains all of the items on the shipping list. If anything is missing or obviously damaged, contact 2B Technologies immediately.

2.2. Setup

2.2.1. Plumbing Connections

The Aqueous Ozone Monitor requires a slightly pressurized source of the water to be analyzed. The inlet pressure should be adjusted to produce a flow rate through the injection loop of at least 30 cc/min. This requires a differential pressure across the **Inlet** and **Return** connectors of at least ~0.3 psi, corresponding to ~8 inches of water. For safety reasons and to prevent leaks, the pressure at the **Inlet** should not exceed 60 psi. The **Inlet** pressure can be adjusted using a needle valve or other pressure regulator to achieve the desired flow rate. To set up the proper flow rate, attach the water source to be sampled to the Inlet connector located at the lower left bottom of the instrument and attach a return line or to the **Return** connector (see Fig. 2.1). The return can be connected to the ozonized water source at a lower pressure point; i.e., downstream in a flowing system or at a higher level (~1-5 feet higher) in a static tank. With no dissolved ozone present, the flow rate into or out of the instrument can be measured using a rotameter or other water flow meter in line and adjusted to be in the range 30-200 mL/min, with 50 mL/min considered optimal.

Fig. 2.1. External Plumbing Connections located on the bottom of the NEMA enclosure.

Alternatively, the Return can be plumbed to a waste stream. Note that water exiting the **Return** will contain dissolved ozone and pose a health hazard due to off gassing of ozone if not disposed of safely.

Also connect tubing to the **Drain** connector. Both air and partially ozone-stripped water exit the drain at a pressure of a few psi. The **Drain** can be plumbed to return to the ozone/water source if the source is not pressurized. Otherwise the **Drain** fluent must be disposed of through a system designed to remove ozone. Note that water exiting the **Drain** will contain both air and water containing ozone and pose a health hazard due to off gassing of ozone if not disposed of safely.

All connectors are ¼ inch stainless steel Swagelok fittings. The inlet tubing should be made of PTFE (Teflon®), PFA, FEP , PVDF or some other inert material that does not destroy ozone. The length of tubing should be kept as short as possible (preferably not more than a few feet) to minimize ozone destruction within the residence time within the inlet tubing. Tygon® or polypropylene (which may look like Teflon) should not be used. FEP-lined Tygon is recommened. This tubing provides the flexibility of Tygon with the inertness of FEP.

2.2.2. Electrical Connections

Figure 2.2 shows the wiring harness for the UV-106-W Aqueous Ozone Monitor. A single cable connects to the lower left side of the Aqueous Ozone Monitor. The red and black wires are attached to a power connector for the provided 12 VDC power pack. This power pack can be connected to any 120 or 240 VAC source. A 9-pin connector is provided to attach to the provided “straight through” serial cable using black, brown and yellow wires. Bare wires are provided for the analog outputs with white (ground), purple (4-20 mA) and orange (2.5 V).

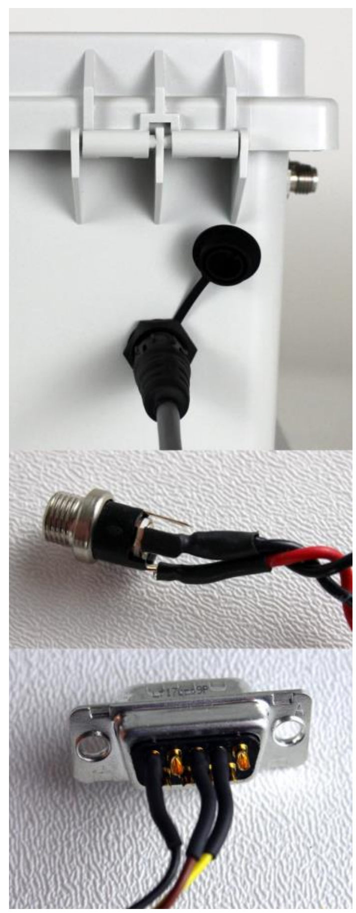

Fig. 2.2. Wiring harness for Model UV-106-W.

2.2.3. Operation of the Aqueous Ozone Monitor

To operate the Aqueous Ozone Monitor, connect it to the 12 VDC power adapter supplied with the instrument. The power adapter may be used with either 110 or 220 VAC at 50 or 60 Hz. Other DC sources in the range 11-14 V such as batteries or other power supplies also may used provided that they can supply up to 2.5 amp of current.

Once turned on, the instrument will display the version number of the software installed on the microprocessor.

After a few seconds, the instrument will start displaying readings for ozone. The first dozen readings (requiring about two minutes) will be spurious, with large positive and negative swings due to the rapid warm up of the lamp and electronics. Also, dissolved ozone measurements may be inaccurate during the 10-20 minutes required for the lamp, photodiode, and internal temperature of the absorption cell to stabilize.

2.3. Measurement of the Zero Offset

The electronic zero of the instrument may be measured by sampling water containing no dissolved ozone such as tap water. For an accurate measurement, the instrument must have been turned on long enough for the internal temperature to stabilize, which at room temperature is usually about 20 minutes. The observed offset, which usually is less than $\pm$ 0.05 ppm, can be corrected for by changing the offset calibration parameter (Z) from the front panel, as described below.

2.4. Collecting Data over the Serial Port in Real Time

To transmit data to a computer over the serial port in real time, connect the Aqueous Ozone Monitor to the serial port of the computer using the 9-pin cable provided. Note that this is a "straight-through" female-female serial cable. A "cross-over" cable will not work. Start your data acquisition software, preferably using the 2B Technologies Display and Graphing Software (free download from http://twobtech.com/software.htm). Other terminal emulation software such as HyperTerminal (a program provided with Windows) or Tera Term Pro may be used as well.

The dissolved ozone concentration, detection cell temperature, cell pressure, flow rate, light intensity I_o, average light intensity I, calculated percent of ozone in the tail of the ozone profile, ozone decay constant k, date and time are sent as comma-delimited ASCII text to the serial and USB ports (2400, 9600 or 3800 baud as selected in menu; 8 bits; no parity; 1 stop bit) every ten seconds, 1 minute, 5 minutes, or 1 hour, depending on the averaging time selected from the instrument menu. Time is provided in 24-hour (military) format, and the date is given in European style (day/month/year).

A typical data line would read:

5.606,30.8,857.94,1937.68,1.440997,1.396549,24.04,0.27,20/07/14,21:19:37

where:

Ozone = 5.606 ppm
Cell temperature = 30.8 ^oC (units selected)
Cell pressure = 857.94 mbar (units selected)
Flow rate = 1937.68 cc/min (volumetric)
Photodiode Voltage I_o = 1.44097 volts

Average Photodiode Voltage I =1.396549 volts
%Ozone in Tail = 24.04
Date = July 20, 2014
Time = 7:19:37 pm

If outputting logged data, the output serial data line will be preceded by the log number; e.g.,

2893, 5.606,30.8,857.94,1937.68,1.440997,1.396549,24.04,0.27,20/07/14,21:19:37

where 2893 is the log number.

In addition to data lines, messages are written to the serial port when logging is begun or ended, when transmission of data from the logger is begun and ended, when data collection is interrupted (e.g., due to a power failure) and when the averaging time is changed.

2.5. Menu

The following diagram summarizes the complete instrument Menu.

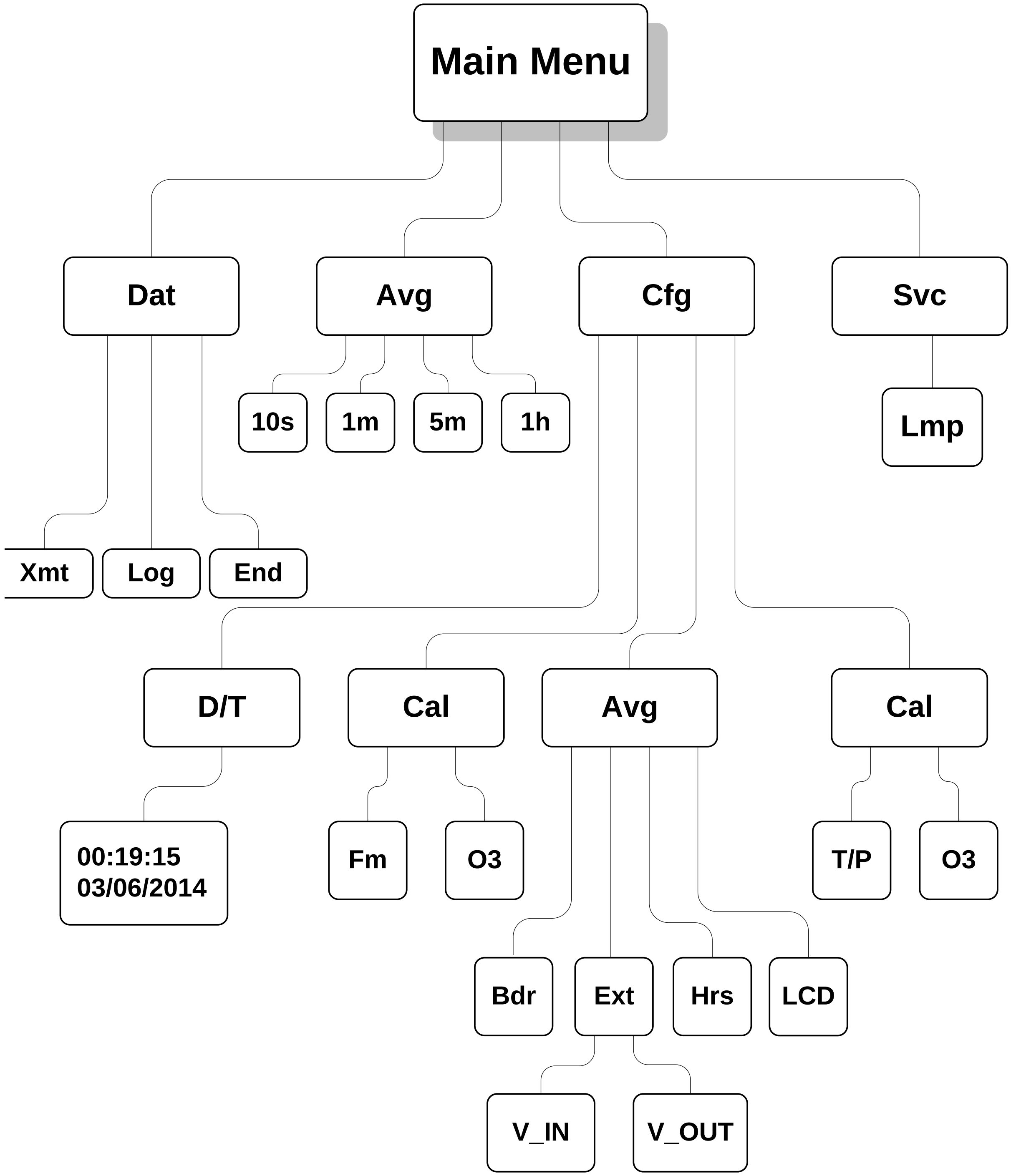

Figure 2.1. Instrument Menu Tree.

2.6. Selecting the Menu

The menu is accessed using the Select button on the front panel of the instrument. To reach the menu *hold in* the Select button (for up to a 5 seconds) until

Menu

is displayed, then release the Select button. After a brief period the main menu will appear:

Menu
Dat Avg Cfg Lmp ←

where **Dat**, **Avg**, **Cfg** and **Lmp** are submenus that may be selected. A blinking cursor will show across the **D** of the **Dat** submenu. The Select button may be rotated clockwise or counterclockwise to move the cursor under the first letter of one of the other submenus. To select a particular submenu, move the cursor under the first letter of a submenu and momentarily press ("click") the Select button. To exit the Main Menu and begin making measurements again, select and click on the left arrow (←).

When first turned on, the instrument will start making measurements at a rate of once every 10 s. Data may be logged in the internal data logger. Up to 16,368 data lines containing log number, ozone mixing ratio, cell temperature, cell pressure, gas flow rate, photodiode voltage, light intensities Io and I, percent ozone in the tail of the ozone profile, time and date may be stored in internal memory, corresponding to an operational time of 1.9 days. Averaging times of 1 min, 5 min and 1 hr also may be selected from the menu, thereby allowing the instrument to operate for 11 days, 57 days and 1.9 years, respectively, before filling the memory. Details of averaging and logging of data are described in sections immediately below.

2.7. Selecting the Averaging Time

Hold down the Select button to obtain the **Menu**. Select and click on **Avg** to obtain the **Avg** menu:

Avg Menu
10s 1m 5m 1h ←

Use single clicks to move the cursor to **10s**, **1m**, **5m** or **1h** for averaging times of 10 s (no averaging), 1 min, 5 min or 1 hr averaging, respectively. Then click on the averaging time you want to use. You will be returned to the main **Menu.** To exit the menu and start acquiring data, click on ← again.

The Ozone Monitor will then begin displaying the most recent 10-s measurement and the current average value. For example, if 10 second averaging (no averaging) is selected, the display might read

O3= 3.21 ppm

13:05 02/05/14

where the current 10-s measurement is 3.21 ppm the time is 1:05 pm (24 hr clock), and the date is 5 February 2014 (European date format). If any other averaging time has been selected, the above display will be replaced by

O3= 3.21 ppm
Avg O3= 3.25 ppb

13:05 02/05/14

for example, where the most recent average value of ozone computed is 3.25 ppm.

2.8. To Log Data

Select the **Dat** submenu from the Main Menu using the Select button. The display will now show:

Dat Menu
Xmt Log End ←

To start logging data, rotate the Select switch to move the cursor to **Log** and click to select the logging mode. You will then receive the prompt:

Logging Menu
Resume Restart ←

Select and click on **Restart** to begin a new data log or select **Resume** to add data to a current data log. If you chose Restart, you will receive the following warning and choice of whether to overwrite all data in the logger:

This will overwrite
All existing data.
Are you sure?
No Yes ←

Warning: If you choose Yes, all data previously stored in the logger will be irretrievably lost. If you have data in the logger that you want to keep, be sure to download it (see below) before starting logging. Click on **Yes** if you are sure you want to erase all stored data start a new data log.

If data are being logged, alternate screens show the log number and the number of new measurements made for the next average (minus 1) in place of the date and time; e.g.,

O3= 3.21 ppm
Avg O3= 3.25 ppb

Log= 193:4

where **Avg O3** is the average ozone value most recently written to the logger, and the current log number is 193. The “4” in 193:4 refers to the number of 10-s data points that have been measured so far for inclusion in the next average to be displayed and logged. If 1-min averaging is used, this number will increment from 0 to 5; for 5-min averaging, the number will increment from 0 to 29; and for 1-hr averaging, it will increment from 0 to 359. This number is displayed so that the user will know how many more 10-s measurements need to be made before a new average is displayed and logged.

If there is a power failure while the instrument is in the logging mode, logging will resume after power is restored. A note of “Data Interruption” will be written to the logger prior to writing the first new data line. The instrument can accommodate multiple data interruptions due to power failures. For example, one can purposely switch the instrument off, move to another location and restart logging simply by turning the instrument back on. Data sets will be separated by the data interrupt message.

2.9. To Stop Logging Data

Hold in the Select button to obtain the **Menu**. Go to the **Dat** submenu by clicking on **Dat**. Choose and click on the **End** function. This will end data logging. You may now return to the **Dat** menu to transmit the data to a computer by clicking on **Xmt** (see below). The stored data will reside in memory (even when new measurements are being made whether the instrument is logging or not) and can be transmitted using the **Xmt** function as often as you like.

You can append the logged data with additional data by choosing **Resume** in the Log submenu. As discussed above, all stored data are lost once logging is started again using the **Restart** function. Thus, you should always transmit your data to a computer before restarting logging.

If you fail to **End** logging prior to transmitting the data using the **Xmt** function, the instrument will automatically execute the **End** function for you prior to transmitting the data.

2.10. To View the Flow Rate, Lamp Voltage and % Ozone in Tail on the LCD

Rotate the scroll switch in either direction to view the volumetric flow rate during normal operation. Additional diagnostic information will be displayed on the LCD:

O3= 3.21 ppm
Avg O3= 3.25 ppb
Flow = 985 cc/min
Lamp = 1.4 V   Tail = 25.573

Here, the LCD show the current air flow rate, lamp intensity in volts and the most recent measurement of the percent of ozone in the tail.

2.11. To Transmit Logged Data to a Computer Using the USB or Serial Port

Connect the USB or serial port of the instrument to your computer using the supplied cable. Enable a data acquisition program on the computer such as the 2B Technologies Display and Graphing Software, which can be downloaded at:

http://twobtech.com/software.htm

Alternatively, HyperTerminal can be used (available on most Windows® platforms, usually in Start/All Programs/Accessories/Communications/Hyper Terminal) or Terra Term, which can be downloaded at:

http://logmett.com/index.php?/download/tera-term-483-freeware.html

The correct settings for receiving data are: chosen baud rate (4800, 19200 or 38400); 8 bits; no parity; 1 stop bit. (The baud rate for data transmission is set in the **Cfg→I/O→Bdr** menu as described below and remains.)

Click the Select button to obtain the **Main Menu**. Go to the **Dat** submenu by clicking on **Dat**. Next, click on **Xmt**. The message "Logged Data" will be written to the serial port, followed by a carriage return and all of the lines of logged data. After all data are transmitted, the message "End of Logged Data" and a carriage return are written. After transmission is complete, you can return to any position in the menu or resume ozone measurements. The logged data continues to be available for transmission until a new data log is started.

2.12. To Set the Calibration Parameters

The instrument is calibrated at the factory where slope (S) and offset (Z) parameters are entered into the instrument's memory. These preset calibration parameters are given in the instrument's Birth Certificate and recorded on the calibration sticker on the instrument case. However, the calibration parameters may be changed by the user. For example, the instrument may develop a slight positive or negative offset due to temperature change or contamination. This offset may be removed by changing the offset (**Z**) calibration parameter. Any significant change in the slope (sensitivity, gain) calibration parameter (**S**) of the instrument is likely due to a serious problem such as contamination, an air leak or obstruction of air flow, but it also can be adjusted. Once the zero of the instrument is corrected by sampling ozone-free water and adjusting the **Z** parameter, the slope may be adjusted so that the instrument readout agrees with the readout from another instrument whose calibration is considered to be accurate.

To change the calibration parameters, choose the **Cfg** submenu from the main **Menu** and click on **Cal** to obtain the display

Cal Menu
Fm O3 ←

Click on the **Fm** submenu to display the calibration factor for the air flow meter.

Fm Cal Menu
Fm= 0.92 ←

This is a multiplicative factor that will increase the indicated flow rate if you increase the value. Adjust this value to correct the measured flow rate when comparing it to a calibrated volumetric flow meter connected to the air outlet of the instrument..

Click on the **O3** calibration submenu to obtain, for example:

Cal Menu
Z= -15 S= 1.01

Here Z is the offset applied (in this case -15 ppb; i.e., -0.015 ppm) and S is the slope applied (in this case 1.01). The value of Z is added to the measured ozone value, and the value of S is then multiplied by the measured ozone value. During calibration Z is set to 0 and S set to 1.00, if the instrument reads an average of 18 ppb (0.018 ppm) while sampling ozone-free water, the value of Z should be set to –18. If after correction for the zero, the instrument consistently reads 2% low, the value of S should be set to 1.02.

When the **Cal Menu** first appears, the **Z** will be underlined with a cursor. You may rotate the Select switch to choose the calibration parameter **S** or **Z**. A single click on **S** or **Z** will select that parameter for change and activate a blinking cursor. Once **S** or **Z** is selected, its value can be changed by rotating the Select switch to the left or right. After choosing the desired value, a click turns off the blinking cursor and allows you to scroll to the other parameter or to ← to exit the submenu. Once the values of **Z** and **S** are set, clicking on ← will return the display to the **Cal** menu. The calibration parameters reside in non-volatile memory and are not affected by power failures.

2.13. To Set the Time and Date

From the **Main Menu**, select the **Cfg** submenu. Next, select the **D/T** submenu. The display will read, for example:

D/T: 14:32:21 ←
17/10/2010

meaning that it is 21 seconds after 2:32 p.m. on October 17, 2010 (military time and European date). To change a number in the date and time, rotate the Select switch to underline the numeral you want to change. A single click then causes a blinking cursor to cover that numeral. The number can then be changed by rotating the Select switch. Once the number is correct, click on the Select switch to turn off the blinking cursor. You may now rotate the Select switch to choose another numeral to change. Once the time and date is correct, clicking on ← will set the internal clock to that time and return the display to the **Cfg** menu. As in setting a digital watch, the seconds should be set in advance of the real time since the clock starts to run again only when the set time is entered; in this case by clicking on ←.

2.14. Accessing the Serial Menu

Measurements and logging tasks can be accessed via the serial port or the USB using a terminal emulator such as Tera Term or HyperTerminal running on an attached computer. Commands can be sent using the terminal emulator set with the properties listed in the section 2.4 of this manual entitled *"Collecting Data over the Serial Port in Real Time"*. Listed below are the lower case letters that are commands for performing certain operations while the instrument continues to measure:

l Start logging (also available during measurements).
b Resume logging (also available during measurements).
t End logging and transmit data (also available during measurements).
e End logging (also available during measurements).
a Set average and output frequency.
z Set the zero offset calibration factor.
s Set the slope calibration factor.
f Set the flow calibration factor.
c Set the time and date.
d Turns the LCD backlight on.
g Turns the LCD backlight off.
p Performs lamp test.
h Output the serial header(also available during measurements).
w Runs 100 samples to calibrate sample loop size.
o Toggle output of photodiode measurements.
x Exit menu

2.15. Collecting Data from the Analog Output

The data may be read or logged in real time using a data logger attached to bare wires provided for voltage (0-2.5 V) output and current output (4-20 mA).

To change the analog output voltage scaling factor, go to **Menu/Cfg/I/O/Ext/V_OUT**. The display will read for example:

2.5V=00050 ppm
20mA=00020 ppm ←

Here, the output scaling factor is set as 2.5 Volt (full scale) = 50 ppm; i.e. 1 Volt = 20 ppm. Also, the current output will be scaled such that the full scale of 20 mA corresponds to 20 ppm. A reading of zero ozone concentration will be output as 0 V and as 4 mA. You can use the select switch to change the scaling factor to the value of your choice by selecting and changing the individual digits in the scaling factor of either the voltage or current. Thus, the instrument is not limited to a fixed number of "ranges" common to most ozone monitors. Instead, any range can be defined.

2.16. To Change the Baud Rate

The baud rate for transmission of data to a computer over the USB or serial port may be changed by going to **Menu/Cfg/I/O/Bdr** to obtain:

Baud Menu
2400 9600 36400 ←

Choosing a baud rate will automatically return you to the **I/O** submenu.

2.17. To Read the Number of Hours of Ozone Monitor Use

The instrument keeps track of the total number of hours of use. This is helpful for determining when the instrument should be serviced, a pump replaced, etc. To read the number of hours of operation choose **Menu/Cfg/I/O/Hrs**. Click the Select Switch to exit.

2.18. To Change the Ozone, Temperature and Pressure Measurement Units

From the **Cfg** submenu, choose the **Unt** submenu:

Unt Menu
T/P O3 ←

Choose O3 to change the ozone units:

O3 Units Menu
Ozone: ppm ←

Select **ppm**, depress the select switch to obtain a blinking cursor and rotate the select switch to choose between units of ppm, g/m^3, µg/L, mg/L and ppb. Note that all the units except ppb are the same, so you are only changing the text displayed. Press the select switch again to remove the blinking cursor, and return to the **Unt** menu using the left arrow. Ozone concentrations will now be calculated and reported in the chosen units.

Temperature and pressure a measured within the detection cell to correct the measured mass flow rate to volumetric flow rate. Select T/P from the **Unt** submenu to change the units reported for temperature and pressure:

T/P Units Menu
T:C P:mbar ←

You may now select units of degrees C or K for temperature and mbar or torr for pressure using the same procedure used to set the units for ozone concentration.

2.19. Lamp Test

If the instrument is excessively noisy (standard deviation greater than 2 ppb) or always reads near zero in the presence of ozone, it is useful to perform the lamp test to make sure that the lamp is turning on and does not fluctuate too rapidly. Before performing the lamp test, allow the instrument to warm up for at least twenty minutes.

Choose **Lmp** from the **Svc** (Service) menu. The display will momentarily read "**Lamp Test**". The photodiode voltage will then be displayed, and after a few lamp measurements have been made, the electronic offset and standard deviation also will be displayed as, for example:

PDV= 0.89801 V
1.2+/-1.85 ←

The photodiode voltage (PDV) is a measure of the lamp intensity and should be in the range 0.6-2.2 volts. Since absorbance is a ratio measurement, the absolute value of the voltage is not particularly important. However, above 2.5 volts, which could occur if the instrument is allowed to become too hot, the photodiode is saturated and the calculated ozone concentration will be zero. Photodiode voltage less than 0.6 volts is indicative of either a weak lamp or a dirty detection cell and may result in a noisy measurement. The photodiode voltage will typically increase as the instrument warms up. Lamp drift is continuously monitored and corrected for in the firmware and thus has very little effect on the measured ozone concentration. Once the instrument is warmed up, fluctuations in photodiode voltage should be limited primarily to the last digit displayed. The lamp test also calculates an electronic offset and standard deviation of the measurement itself, displayed in the above example as 1.2 ppb for the electronic offset and +/-1.85 for the standard deviation. The standard deviation is a quantitative measure of the lamp and associated electronic noise. Electronic offsets should normally be -10 to 10 ppb equivalent. After running the lamp test for a few minutes, values above 5.00for the standard deviation usually indicate an excessively noisy lamp. Lamps seldom “burn out” but may become noisy with time and need to be replaced. Some lamps become noisy after only a short period, while others will be extremely stable for years. If your lamp fails the lamp test during the first year of operation, contact us for a new lamp under the instrument warranty. Contamination of the detection cell may also cause a high standard deviation, in which case the flow path should be cleaned with methanol and the internal ozone scrubber replaced. Please contact us for detailed procedures if you want to perform these operations on site.

3. MAINTENANCE/TROUBLESHOOTING

The Aqueous Ozone Monitor is designed to be nearly maintenance-free. The only component that requires routine maintenance is the ozone scrubber, which should be changed at least once annually.

To change the ozone scrubber, remove the two screws that hold the interior door closed and open the door to expose the mechanical bench. The ozone scrubber consists of two ozone scrubbing cartridges in series. The ozone scrubber can easily be replaced by disconnecting the silicone attached to each end and connecting a new one in its place.

Other components with a limited lifetime are the air pump (~15,000 hours), lamp (~20,000 hours) and solenoid valves (rarely fail). It is recommended that the instrument we returned to 2B Technologies if any of these components fail. Alternatively, the user may install these components at their own risk. In that case, please contact 2B Technologies for instructions.

The following are indications of various instrument malfunctions.

Air Pump Failure: The instrument will not make a humming sound. Also, the circuit breaker may prevent the instrument from powering up if the motor in the air pump develops a short.

Lamp Failure: The ozone measurements will be erratic and the Lamp Test will show 0.0 volts for the photodiode voltage.

Solenoid Valve Failure: The ozone readings will be low and possibly highly erratic if one or more of the solenoid valves are failing to open and close properly.

Contaminated Air Flow Path: The instrument will typically have a large positive or negative offset.

Help with trouble shooting is provided in the following table.

Table I. *Troubleshooting the Ozone Monitor for performance problems.*

Problem/symptom	Likely cause	Corrective action
Instrument does not turn on.	Power not connected properly or circuit breaker open.	Check external power connection for reverse polarity or a short and wait a few minutes for the thermal circuit breaker to reset.
Instrument turns on then powers off.	Burned out air pump.	Remove cover to circuit board chamber and unplug air pump. Turn instrument on; if it remains running, then the air pump motor is burned out and shorting. Replace air pump.
Display is blank or nonsense.	Bad connection of display to circuit board.	Remove cover to circuit board chamber and reconnect display to circuit board. Check solder connections to display. A new LCD may be required.
Cell temperature reads low by several 10's of degrees.	Absent or loose connection of temperature probe cable to circuit board.	Remove cover to circuit board chamber and reattach connector to circuit board.
Readings are noisy with standard deviations greater than 0.05 ppm.	Lamp output is weak, below 0.6 V on Lamp Test. Flow path contaminated.	Remove covert to circuit board chamber and check lamp connection to circuit board. Run Lamp Test from menu. If photodiode voltage is less than 0.6 V, replace lamp. Clean flow path of optical bench with methanol according to the Cleaning Procedure.

Analog output is constant or does not track front display.	Cable not properly connected between analog output and recording device. Wrong scaling factor selected in menu.	Check continuity of your analog cable to your recording device and make sure correct connector pins are being used. Check and reset analog output scaling factor in the Menu.
Select switch does not work.	Bad solder joint to circuit board or damaged select switch.	Open internal door by removing the two screws and check solder connection to select switch. It may be necessary to replace the select switch.
Serial port does not work.	Wrong serial cable used. Wrong baud rate selected. Wrong computer com port chosen.	A "straight through" serial cable is provided. Some data collection devices require a "cross over" cable in which pins 1 and 3 are exchanged between the two ends of the cable. Use a "cross over" cable or additional connector that switches pins 1 and 3. Make sure that the baud rate chosen in the menu matches the baud rate setting of your data acquisition program. Try choosing other com ports in the data display software.
Required calibration parameters are large (>±0.1 ppm offset and/or >±10% slope) when calibrated against a known aqueous ozone concentration.	Air flow path is contaminated.	Clean flow path with methanol following the Cleaning Procedure.

	One or more solenoid valves are contaminated and not opening and closing properly.	Make sure that both water and air are exiting the instrument. Replace any solenoid valve that is not working properly.
	Air pump is not providing sufficient flow.	As a first check, hold your finger over the air outlet to determine whether air is flowing. Also, rotate Select Switch one click to obtain a display of the air flow rate. Air flow should be greater than 600 cc/min. If the flow rate is lower, check for leaks. If there are no leaks, replace air pump.

2B Technologies offers reasonably priced customer service for instrument repairs. The calibration service includes cleaning of the entire flow path with methanol, testing of all components for proper function, installation of a new internal ozone scrubber and calibration against a NIST-traceable standard. The best way to contact us for service is to log a customer service ticket at www.twobtech.com/techsupport. Normally, you will hear back from us by email within a few hours. Or, call us at +1(303)273-0559.

There is a great deal of technical information about our instruments posted as technical notes at www.twobtech.com/tech_notes.htm. Manuals, brochures, software, cleaning procedures and scientific papers may be downloaded at www.twobtech.com/downloads.htm.

4. INSTRUMENTS PHOTOS

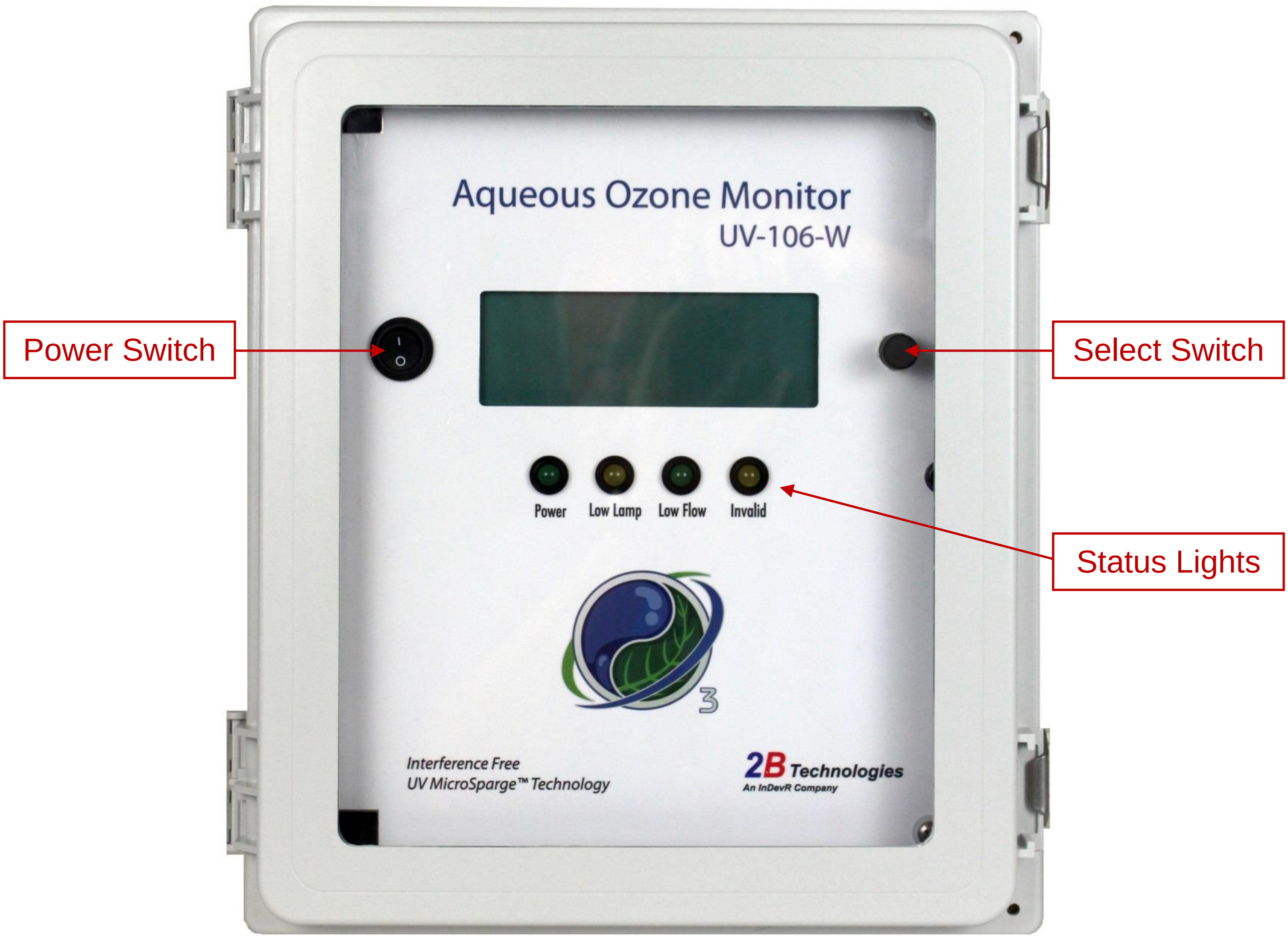

Fig. 4.1. Front View of Model UV-106-W.

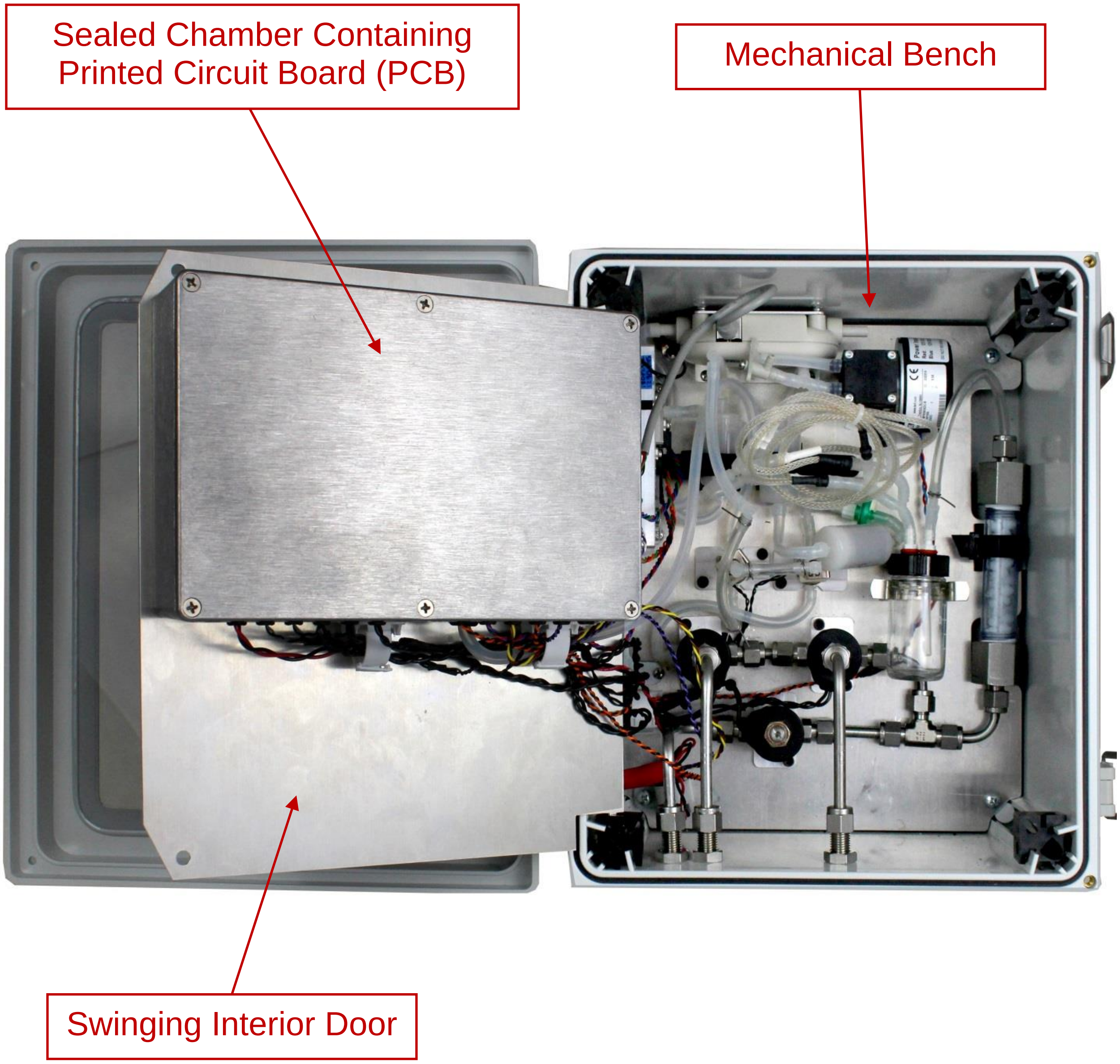

Fig. 4.2. Inside View of Model UV-106-W**.**

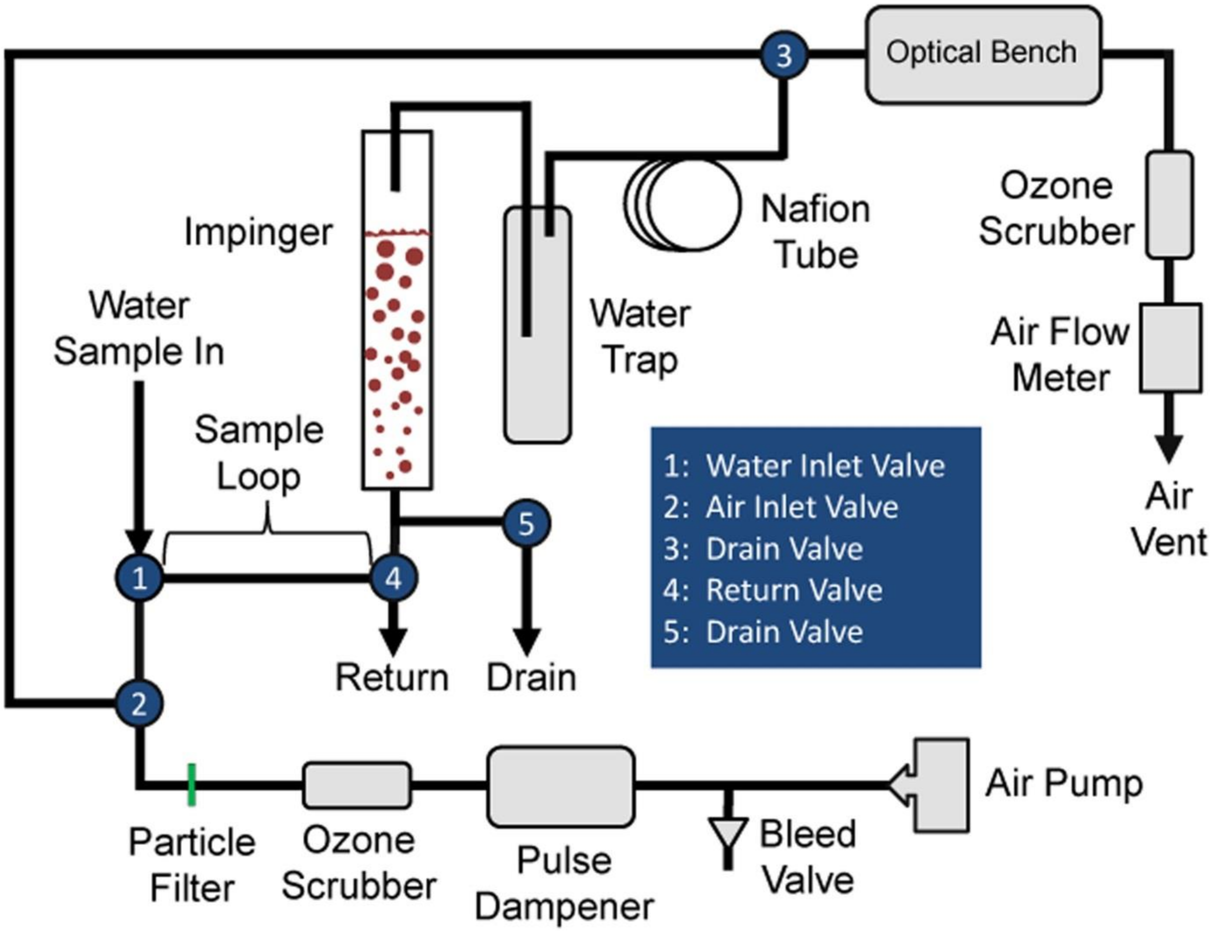

Fig. 4.3. Schematic Diagram of Model UV-106-W Aqueous Ozone Monitor.

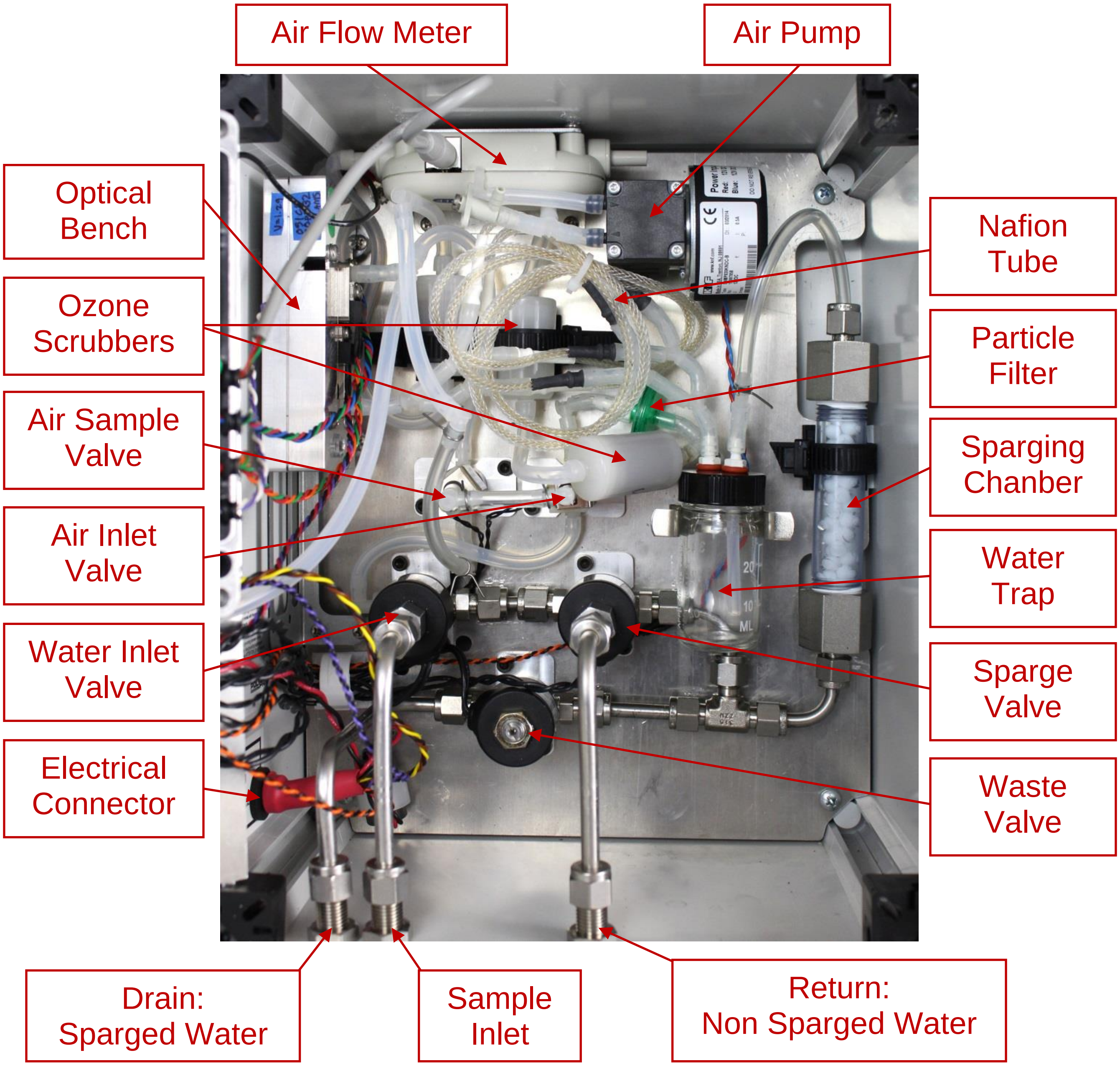

Fig. 4.4. View of Mechanical Bench. Compare to previous figure.

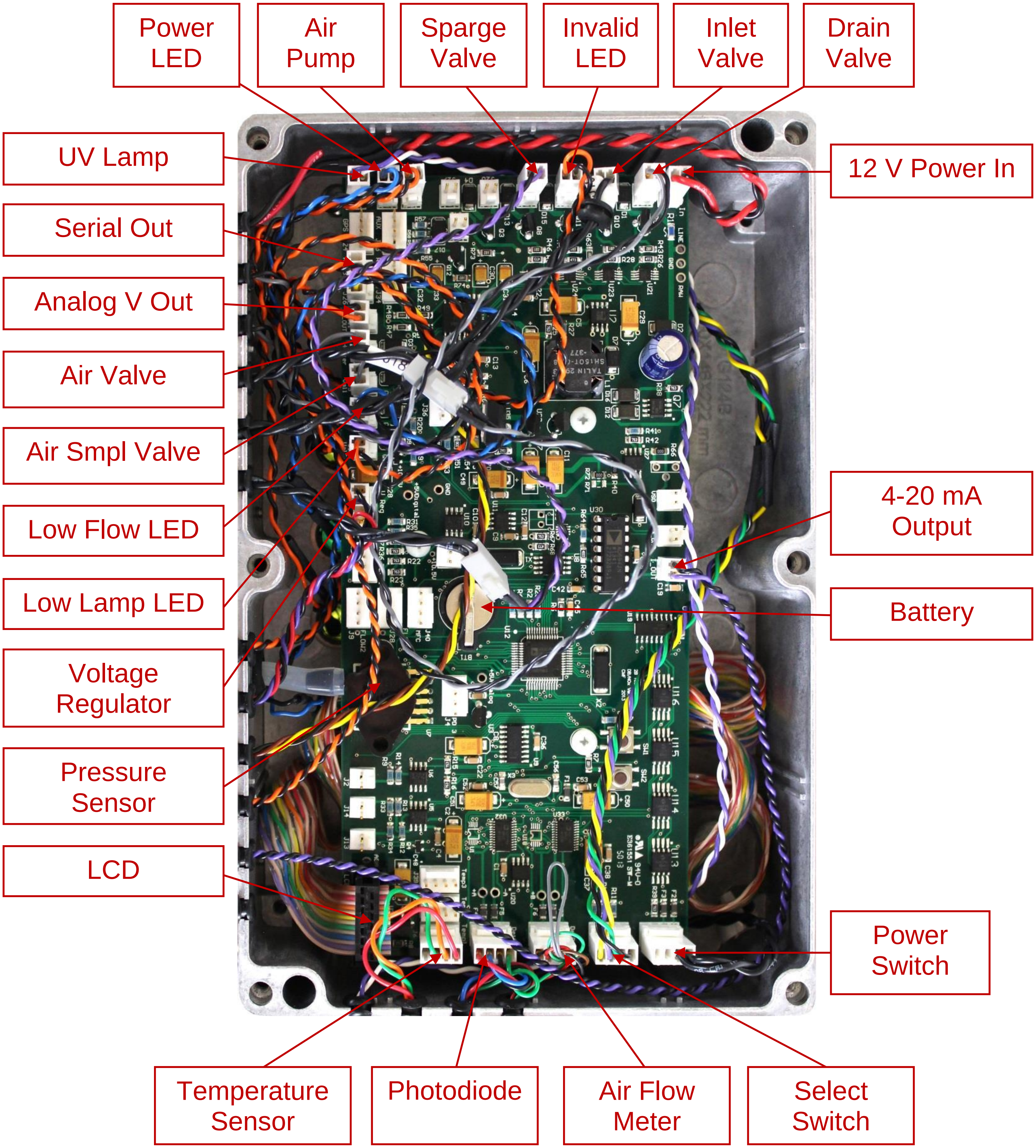

Fig. 4.5. Printed Circuit Board.

5. PARTS LIST

The following list includes those parts that are user serviceable.

Part Number	Description
SCRBINT	Ozone scrubber
SPARGE106W	Sparging Chamber
OZLAMP106	Lamp and inverter
OZVLV3	Air Solenoid valve
OZVLVH2O	Water Solenoid valve
OZDSP106W	LCD display and cable
OZPUMP106	Air pump
PDASSY106	Photodiode assembly and cable
OZCEL106	Absorption cell
SERCABL	Serial port cable (to computer)
TEFTYG	Teflon-lined Tygon® tubing
SILTUB	Silicone tubing

6. SERVICE LOG

Date/ Hours	Calibrated	Cleaned	New O_3 Scrubber	New Pump (main/backup)	New Lamp	Other

Date/ Hours	Calibrated	Cleaned	New O_3 Scrubber	New Pump (main/backup)	New Lamp	Other