

Ozone Monitor

2B Technologies



OPERATION MANUAL

Models 106-H and OEM-106-H

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IDENTIFICATION RECORDS

Record the following information for future reference:

Unit serial number: _____

Warranty start date: _____
(date of receipt)

PRINTING HISTORY

This manual covers the Model 106-H Ozone Monitor used for measurement of High concentration ozone generators over a wide dynamic range extending from 0-20 wt% (0-14 vol%). It also covers the Model 106-OEM-H Ozone Monitor, which does not have the enclosure and can be used for Original Equipment Manufacturer (OEM) applications. New editions of this manual are complete revisions that reflect updates to the instrument itself, as well as clarifications, additions, and other modifications of the text.

Revision A	April 2010
Revision B	September 2010
Revision C	December 2011
Revision D-1 (serial no. 932H and above)	July 2017
Revision D-2	March 2018
In Section 2, clarified the flow information in the Specifications table. In Section 3.18, added reference to our new Technical Note 45 about using the relays.	
Revision E-1 (serial no. 1118H and above)	July 2018
New pressure sensor and optical bench. Changes to associated specifications (power, weight, drift) and photos.	
Revision F-1 (serial no. 1129H and above)	November 2018
Spec for low voltage limit of the reference photodiode changed from 0.6 V to 0.1 V; update to Sections 3.19, 3.20, and 4 regarding photodiode voltages and LED indicator light functionality; correction to serial line output voltage order in Section 3.12.3; updates of all web links; other minor edits.	
Revision F-2 (serial no. 1129H and above)	September 2020
Added Appendix C about installation of the OEM 106. Other minor updates and edits.	
Revision F-3 (serial no. 1129H and above)	February 2021
Corrected units option Ng/m ³ to g/Nm ³ . Added part numbers in Section 8.	

TRADEMARKS & PATENTS

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WARRANTY STATEMENT

2B Technologies 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.

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:

<https://twobtech.com/tech-support.html>

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.

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.


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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, USA, the protection provided by the instrument may be impaired.


ESPAÑOL


 **ATENCIÓN:**
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.

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

ATENCIÓN:
Si este instrumento se usa de una forma no especificada por 2B Technologies, 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 choc qui pourrait être dangereux, déconnectez 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, 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, daß der Anwender zuerst das entsprechende Kapitel in der Bedienungsanleitung lesen sollte.

WARNHINWEIS:
Wenn das Gerät nicht wie durch die Firma 2B Technologies, 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, 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, USA gelden de veiligheidsvoorzieningen niet meer.


CHINESE


 **警告：**
任何需要接触设备内部的操作均可能造成人身伤害。为避免可能的触电危险，请在打开设备前切断电源。

警告：
这个符号  在仪器上表示用户应参考说明书上的操作指南。

警告：
如果仪器没有按照美国2B科技公司指定方式操作，仪器的保护性能会减弱。

JAPANESE

 **警告：**
機器の内部で操作する時、怪我できます。危険な衝撃を回避するために、機器を開ける前に、電源を切断してください。

警告：
機器でこの記号  を見れば、マニュアルを読んでください。

警告：
この機器は2Bテクノロジー会社、USAの指定でなければ、機器の保護が損なえます。

1. OZONE MONITOR INTRODUCTION

The 2B Technologies Model 106-H Ozone Monitor is designed to enable accurate measurements of ozone over a wide dynamic range extending from 0.01 percent by weight in oxygen (wt% O₂) to an upper limit of 20 wt% O₂ based on the well-established technique of absorption of ultraviolet light at 254 nm. The Ozone Monitor is lightweight (4.8 lb, 2.2 kg) and has low power consumption (~3 watt) relative to conventional instruments and is well suited for applications such as:

- Monitoring of ozone generator output
- Monitoring of residual ozone after a cleaning or oxidation process
- Control of industrial ozone processes

The Model 106-H is a flow-through instrument with no air pump. The plumbing is designed for high pressure (up to 50 psig) and partial vacuum.

An OEM version of the Model 106-H is available and its installation is described in Appendix C.

1.1 Theory of Operation

Absorption of UV light has long been used for measurements of ozone 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 in ozone process streams absorb at this wavelength.

Figure 1.1 is a schematic diagram of the Ozone Monitor. Ozone is measured based on the attenuation of light passing through a 0.1 cm absorption cell fitted with sapphire windows. A low-pressure mercury lamp is located on one side of the absorption cell, and a sample 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. A beamsplitter and reference photodiode are used to monitor the lamp intensity without the sample in the beam path. The intensity of light is measured from the reference photodiode (I_o) and from the sample photodiode (I).

Ozone concentration is calculated from the measurements of I_o and I according to the Beer-Lambert Law:

$$C_{O_3} = \frac{1}{\sigma l} \ln \left(\frac{I_o}{I} \right)$$

where l is the path length (0.1 cm) and σ is the absorption cross section for ozone at 254 nm (1.15×10^{-17} cm² molecule⁻¹ or 308 atm⁻¹ cm⁻¹), which is known with an accuracy of approximately 1%. The 2B Technologies instrument uses the same absorption cross section (extinction coefficient) as used in other commercial instruments.

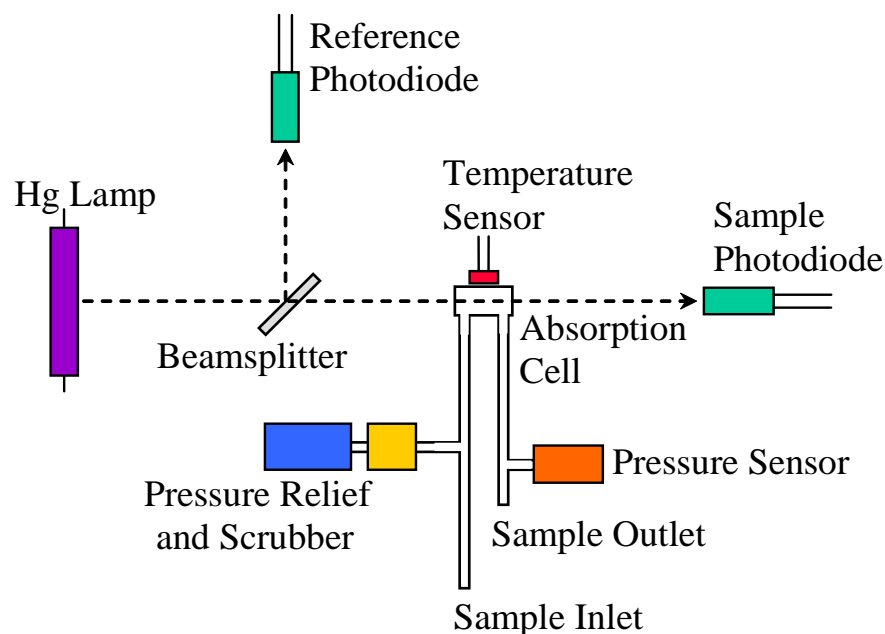


Figure 1.1. Schematic Diagram of the Model 106-H Ozone Monitor.

When there is no ozone in the cell, a difference in light intensity at the reference and sample photodiodes can be expected, and it will cause a zero offset in the readings. This light intensity difference is inherent in the instrument due to the different properties of the two photodiodes, drift in the angle of the beamsplitter, contamination in the cell and thermal drift in any of the optical components. The zero drift has been determined to be less than or equal to 2% of full scale per month, non-cumulative, and can easily be corrected for by using the zero function described below. The zero drift does not affect the slope calibration factor in any way, and the instrument does not need to be recalibrated after performing the zeroing function.

The pressure and temperature within the absorption cell are measured so that the ozone concentration can be expressed as a mixing ratio in percent by volume (vol%). The fraction of the sample that is ozone can then be calculated and used to determine the ozone concentration in percent by weight in either air (wt% air) or oxygen (wt% O₂), in g/m³, or in g/Nm³. The instrument displays and records the cell temperature and pressure in addition to the ozone concentration. The cell pressure is displayed and logged in units of mbar, torr, or psia and the cell temperature in units of either °C, °F, or K.

1.2 Calibration and Zeroing Overview

In principle, the measurement of ozone by UV absorption requires only a zero calibration to account for the different light intensities at the reference and sample photodiodes. However, non-linearity of the photodiode response and electronics can

result in a small measurement error. Therefore, each instrument is compared with a reference ozone monitor calibrated to the International Ozone Association (IOA) buffered KI method. These results are used to calibrate the Ozone Monitor with respect to a slope (gain). The correction for slope is recorded in the instrument Birth Certificate. The slope parameter is entered into the microprocessor prior to shipment.

The user may change the slope parameter from the front panel if desired. It is recommended that the instrument be recalibrated at least once every year and preferably more frequently. The user may perform the calibration (see Section 5), or return the instrument to 2B Technologies for calibration servicing.

The zero may drift due to temperature change or chemical contamination of the absorption cell. As discussed below (Section 3.2.5, Section 3.10, Section 6), an accurate zero correction can be measured from time to time using zero gas and the auto-correct function of the instrument.

2. SPECIFICATIONS: Model 106-H and Model OEM-106-H

Measurement Principle	UV Absorption at 254 nm, single beam
Measurement Interval	2 s
Linear Dynamic Range	0-20 wt%
Resolution	0.01 wt%
Precision (1σ for 10-s average; aka rms noise)	Greater of 0.01 wt% O ₂ or 2% of reading
Limit of Detection (10-s average, 2σ)	0.02 wt%
Accuracy	Greater of 0.01 wt% O ₂ or 2% of reading
Baseline Drift	< 0.02 wt%/day, < 0.05 wt%/month
Sensitivity Drift	< 1%/day, < 3%/year
Calibration	Iodide titration; annual calibration recommended
Measurement Time and Frequency	2 s, 0.5 Hz
Data Averaging Options	10 s, 1 min, 5 min, 1 hr
Response Time, 100% of Step Change	For 2-s output: 4 s, 2 data points For 10-s output: 20 s, 2 data points
Flow Rate	Nominal: Up to 20 L/min; Maximum: 55 L/min 0.5 L/min required for 4-s response time at 2-s output
Data Logger Capacity	32,736 lines (10 s avg. = 3.7 days; 5 min avg = 113 days)

Data Transfer Baud Rates	2400, 4800, 19200
Ozone Units	g m ⁻³ , g Nm ⁻³ , vol%, wt% air, wt% O ₂
Temperature Units	°C, °F, K
Pressure Units	mbar, torr, psi
T and P Corrected	Yes
Operating Temperature Range	0 to 50°C
Operating Altitude Range	0 to 5 km
Operating Pressure Limit	50 psig
Power Requirements	100-240 VAC, 50/60 Hz 11-28 VDC, nominally 250 mA at 12 VDC, 3 watt
Digital Data Outputs	USB, RS232, LCD display
Analog Data Outputs	0-2.5 V Analog, 4-20 mA; user-scalable in menu
Relays with 2 Setpoints	Two available: Relay 1 responds based on user's ozone set points. Relay 2 responds based on user's ozone set points OR responds based on diagnostics (T, P, flow, lamp voltage)
Bluetooth Option Available	Yes
Size	Standard: 3.6 × 7.9 × 9.4 inches (9 × 20 × 24 cm) OEM: 2.5 × 7 × 9 in (6.4 × 17.8 × 22.9 cm)
Weight	Standard: 4.8 lb (2.2 kg) OEM: 3.3 lb (1.5 kg)
Options	Battery, Particle Filter, Bluetooth

3. 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 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.

3.1 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.

3.2 Operation of the Ozone Monitor

3.2.1 Powering the Instrument

To operate the Ozone Monitor, connect it to an external power source and power the instrument on using the power switch. The instrument requires a 12 V DC source which can be supplied by: 1) the 100-240 V AC power adapter, 2) a cigarette lighter adapter plugged into a 12 V DC source such as found in an automobile or many light aircraft, or 3) a 12 V battery. The source can be in the range 11-28 V DC without any detrimental effects on the measurement. When using a battery, be certain to attach the positive (red) and negative (black) wires correctly. Batteries and battery chargers are available from 2B Technologies. A circuit breaker and diode are installed on the circuit board in case of an electrical short or incorrect battery attachment. If activated, the breaker will reset itself after a few minutes.

Lead-acid batteries are available from numerous manufacturers in a wide range of sizes and amp-hour ratings. The larger of these, such as those for automobiles or boats, will supply power for up to several weeks. Battery packs in the correct voltage range may be constructed from nickel-cadmium (rechargeable) or lithium (lightweight but not rechargeable) batteries for operation for a few hours. Battery options available through 2B Technologies may be found on our webpage: <https://www.twobtech.com>.

3.2.2 Initial Startup

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 several readings (requiring about two minutes) will be spurious, with large positive and negative swings due to the rapid warmup of the lamp and electronics. Also, ozone readings may be inaccurate during the first 20-30 minutes required for the lamp, photodiodes, and internal temperature of the absorption cell to stabilize.

3.2.3 Connections to the Instrument

Inlet tubing may be attached to the ¼ inch stainless steel Swagelok fitting on the back of the instrument. For the high concentrations of ozone typically used with the Model 106-H Ozone Monitor, stainless steel tubing is recommended.

3.2.4 Operating Parameters

The Ozone Monitor has an internal pressure relief device that protects the instrument from excessive pressure. The device vents through an ozone scrubber when the inlet pressure exceeds 50 psi and is not meant to be used in normal operation. Although the ozone scrubber is made with an ozone destroying catalyst that has very high ozone capacity, it may not scrub 100% of the ozone if the flow exceeds several liters per minute. Operators of the instrument should not rely on the pressure relief device as a pressure regulating device or expose the instrument to pressures above 50 psi.

Although the instrument compensates for temperature drift, if strong temperature fluctuations are expected, the instrument should be placed in a thermally insulated box.

3.2.5 Checking the Zero Offset

Check the zero measurement occasionally, or if the instrument has not been used recently. The zero offset of the instrument can be measured by first purging the instrument with zero gas at a minimum flow rate of 0.2 L/min for at least 2 minutes. For an accurate measurement, the instrument must have been turned on long enough for the internal temperature to stabilize. The observed offset can be corrected for by running the auto-zeroing function, as described in Section 3.10 of this manual.

3.2.6 Summary of Operating Recommendations

Operating Recommendation	Frequency	Manual Section
Allow ~20 minutes for instrument warmup before taking data	Each startup	3.2.2
Pressure should be below 50 psig	Each use	2, 3.2.4
Flow rates should be below 55 L/min	Each use	2
Inlet tubing should be made of stainless steel	Each use	3.2.3
Check the zero offset	Occasionally or if not used recently	3.2.5, 3.10, 6
Perform multipoint calibration	<ul style="list-style-type: none">• Annually• Any time major disassembly of components is performed• Any time the zero or span checks give results outside of the acceptable limits	1.2, 5
If strong temperature fluctuations are expected, place the instrument in a thermally insulated box	User-defined	3.2.4

3.3 Menu

The following diagram summarizes the complete instrument Menu.

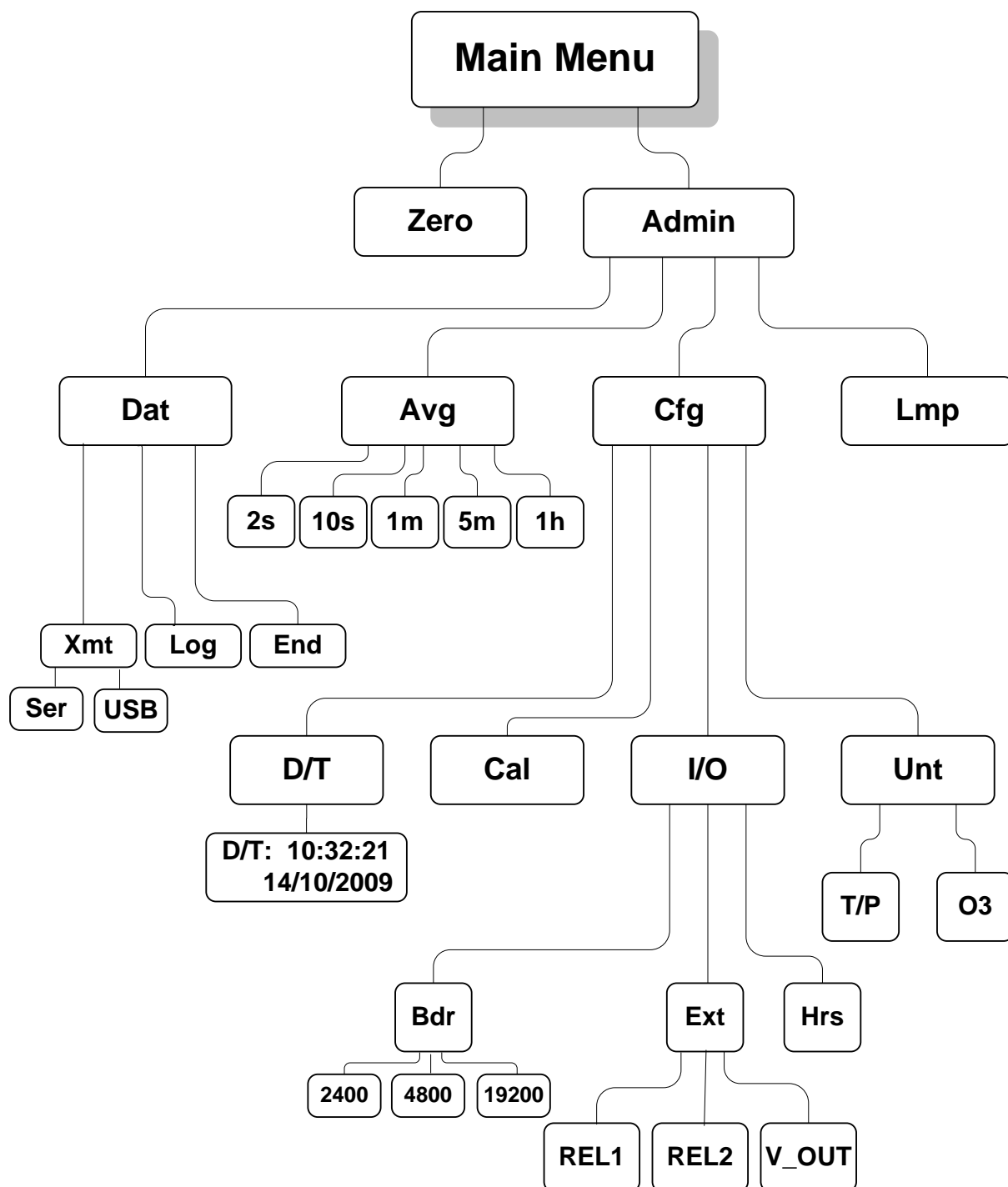


Figure 3.1. Instrument Menu.

3.4 Accessing the Main, Zero, and Admin Menus

When first turned on, the instrument will first display the serial number and then start making measurements. As described in Section 3.2.1, allow a ~20-minute warmup period.

The Main Menu is accessed using the black Select switch on the front panel of the instrument. To reach the Main Menu, press and hold in the Select switch until

Menu

is displayed, then release the Select switch. After a few seconds the Main Menu will appear:

Menu
Zero Admin ←

where **Zero** and **Admin** are submenus that may be selected. A blinking cursor will show across the **Z** of the **Zero** submenu. The Select button may be rotated clockwise or counterclockwise to move the cursor under the first letter of another submenu. 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 (←).

Rotate the Select switch until the cursor is under the “A” in “Admin.” Press the Select switch to enter the **Admin Menu**:

Admin 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 switch may be rotated clockwise or counterclockwise to move the cursor under the first letter of one of the other submenus. Momentarily press (“click”) the Select switch to select a submenu.

To exit the **Admin Menu** and go back to the **Main Menu**, select and click on the left arrow (←). To enter the **Zero Menu**, select and click on it. Exit the Zero Menu by selecting and clicking on the left arrow (←).

To exit the Main Menu and resume measurements, select and click on the left arrow (←).

Refer to Figure 3.1 in Section 3.3 for the various menu functions described in Sections 3.5 through 3.20 below.

3.5 Making Measurements without Averaging or Logging

Access the **Admin Menu** as described in Section 3.4. Select the **Dat** submenu from the **Admin Menu** by rotating and then clicking the Select switch. The display will now show:

Dat Menu
Xmt Log End ←

Click on **End** to make measurements without logging new data. This will return you to the **Admin Menu**. Select the **Avg** submenu and then select "2s" to make measurements without averaging. Click on ← to return to the **Admin Menu** and click ← again to reach the **Main Menu**, and click on ← again to exit the Main Menu and start making measurements without logging or averaging. Note that "←" always takes you up one level in the menu.

The Ozone Monitor will then alternate every 2 seconds between displaying the most recent O₃ measurement along with other instrument measurements. For example, the display might read

O3= 3.48 wt% O2
T=33.3 P=989.7

where the current O₃ measurement is 3.48 wt% O₂, the temperature is 33.3°C and the pressure is 989.7 mbar (see Section 3.9 below for setting other options for the units used for T, P, and O₃). Two seconds later, this display will be followed by

O3= 3.62 wt% O2
15:07 19/07/17

showing that the time is 3:07 p.m. and the date is 19 July 2017.

3.6 Data Averaging and Data Logging Using the Menu

3.6.1 To Average the Data without Logging

Averaging modes can be selected by choosing **Avg** from the **Admin Menu**:

Avg Menu
2s 10s 1m 5m 1h ←

Rotate the Select switch to move the cursor to **10s**, **1m**, **5m** or **1h** for averaging. Then click on the averaging time you want to use. You will be returned to the **Admin Menu**. To exit the Admin Menu and the Main Menu and start acquiring data, click on ← in each case.

When 2s is selected, the rapid raw output of the monitor is viewed every 2 seconds. When 10s is selected, the unit is in the default operating mode. In this mode, the average of five 2-s measurements is displayed and updated. When averaging for 1m, 5m, or 1h is selected, the first of the two displays discussed above in Section 3.5 will alternate with a display of the average, such as

Avg O3= 3.53 wt
15:07 19/07/17

for example, where the most recent average value of ozone computed is 3.53 wt% O₂ (note, because of character limits, only “wt” is displayed), the time of the measurement is 3:07 p.m. and the date is 19 July 2017.

Note that entering the menu will interrupt the averaging interval that is in progress, and the averaging interval will start over when the menu is exited and measuring is resumed.

Averaged data may be logged, thereby greatly extending the length of time that the internal data logger can be used (see next section).

3.6.2 To Log Data

Data may be logged in the internal data logger. Up to 32,736 data lines containing log number, ozone concentration, internal (cell) temperature, internal (cell) pressure, reference photodiode voltage, sample photodiode voltage, date, and time may be stored in internal memory. Measurement output of 2 s, and averaging options of 10 s, 1 min, 5 min and 1 hr may be selected from the menu (see below), thereby allowing the instrument to operate and log data for 18 hours, 3.8 days, 22.7 days, 113 days and 3.7 years, respectively, before filling the memory.

To begin logging data, select the **Dat** submenu from the Admin Menu using the Select switch. 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:

Overwrite Data?
No Yes ←

Warning: *If you start logging, 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 Section 3.14 below) before starting logging.

Click on **Yes** if you are sure you want to start logging new data. This will return you to the **Dat** submenu. Click on ← to return to the Admin Menu, click on ← again to reach the Main Menu, and click on ← again to exit the Main Menu and start making measurements. Note that “←” always takes you up one level in the menu.

When data are being logged, the log number and number of new measurements made for the next average (minus 1) are displayed in place of the data and time; e.g.,

Avg O3= 3.53 wt
Log= 193:4

where **Avg O3** is the average ozone value most recently written to the logger, and the current log number is 193. *(Note that when the average is displayed, the units are truncated. Refer to the instantaneous reading for the full units of wt% O₂, wt% air, g/m³, etc.)* The “4” in 193:4 refers to the number of 2-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 29; for 5-min averaging, the number will increment from 0 to 149; and for 1-hr averaging, it will increment from 0 to 1799. This number is displayed so that the user will know how many more 2-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.

Note that entering the menu will interrupt the averaging interval that is in progress, and the averaging interval will start over when the menu is exited and measuring is resumed.

3.7 To Stop Logging Data

Hold in the Select switch to obtain the **Main Menu**. Go to the **Admin Menu** and then the **Dat** submenu. Choose and click on the **End** function. This will end data logging. You may now return to the **Dat** submenu to transmit the data to a computer by clicking on **Xmt** (see Section 3.14 below). The stored data will reside in memory (even when new measurements are being made) and can be transmitted using the **Xmt** function as often as you like. However, all stored data are lost once logging is started again using the **Log** 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.

3.8 To Set the Time and Date

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

D/T: 14:32:21 ←
17/10/2016

meaning that it is 21 seconds after 2:32 p.m. on October 17, 2016 (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 exiting all menus by clicking on ←, and resuming measurements.

3.9 To Change the Ozone, Temperature, and Pressure Measurement Units

From the **Main / Admin / Cfg** submenu, choose the **Unt** submenu:

Unt Menu
T/P O3 ←

Choose O3 to change the ozone units:

O3 Units Menu
Ozone: vol% ←

Select the units displayed (e.g., vol% above), depress the select switch to obtain a blinking cursor and rotate the select switch to choose between units of percent by weight in oxygen (Wt%O₂), percent by weight in air (Wt%air), grams per normalized cubic meter (g/Nm³, normalized to 1 atm and 0°C), grams per cubic meter (g/m³) or percent by volume (Vol%). 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.

Select T/P from the **Unt** submenu to change the temperature and pressure units:

T/P Units Menu
T:C P:mbar ←

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

3.10 To Auto-Zero the Instrument

Check the zero measurement occasionally, or if the instrument has not been used recently. The instrument has an auto-zeroing function to enable easy zeroing.

First, purge the instrument with zero gas at a minimum flow rate of 0.2 L/min for at least 2 minutes. For an accurate measurement, the instrument must have been turned on long enough for the internal temperature to stabilize (at least 20 minutes).

From the **Main** Menu, select and click on **Zero** to display:

Providing Zero
Air? Yes Cancel

Select **Yes**. You will then see the status message:

Zeroing...

When the zeroing function is complete, you will see the status message:

Zeroing...
Found New Zero

The Ozone Monitor will then exit the **Menu** and return to measuring ozone.

3.11 To Change the Calibration Parameters

The instrument is calibrated at the factory where a slope (S) parameter is entered into the instrument's memory. This preset calibration parameter is given in the instrument's Birth Certificate and recorded on the calibration sticker inside the instrument. However, the calibration parameters slope (S) and offset (Z, which in the Model 106-H must be in units of vol%) may be changed by the user. For example, it may be desirable to provide a positive offset by a known amount (e.g., 0.10 vol%) if the analog output is being used for external data logging since the analog voltage output does not go negative below zero vol%, and the current output does not go below 4 mA. Because of noise and/or an inherent offset, some measured values will be below zero at very low ozone concentrations or while zeroing the instrument with zero gas. Also, the instrument zero may drift by a few hundredths of 1 vol% over time. For this reason, zeroing of the instrument using zero gas to determine the offset is recommended (see Section 3.10 and Section 6). Any change in the slope (gain) of the instrument is likely due to a serious problem such as contamination, but it also can be adjusted. Once the zero of the instrument is corrected, the slope may be adjusted so that the instrument readout agrees with the readout from another instrument whose calibration is considered to be accurate (see Section 5).

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

Cal Menu (%vol)
Z= 0.03 S= 1.012

Here Z is an applied offset (in this case 0.03 vol%) and S is the slope applied (in this case 1.012). The value of Z will be 0.00 if you have performed the auto-zeroing procedure described above. You can provide an offset, however, by changing the value of Z here. When reporting ozone, the value of S is multiplied by the measured ozone value and then the value of Z is added. During calibration, the instrument is first auto-zeroed and checked to make sure that a reading of zero is obtained with sampling air or oxygen containing no ozone. The value of S is set to 1.000 and ozone having a known concentration is measured. If, for example, the instrument consistently reads 2.5% low, the value of S is then set to 1.025. If an offset is desired (e.g., when using an analog output to record the data), the value of Z may then be adjusted to the value of the desired offset.

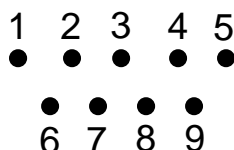
When the **Cal Menu** first appears, the **Z** will be underlined with a cursor. You may rotate the Select switch to choose the calibration parameter **S** or **Z**. A single click on **S** or **Z** will select that parameter for change and activate a blinking cursor. Once **S** or **Z** is selected, 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, another click on ← to the **Cfg** menu, and further clicks on ← will lead back to the **Admin** and **Main** menus and

then back to measuring. The calibration parameters reside in non-volatile memory and are not affected by power failures.

3.12 Collecting Data over the USB or Serial Port in Real Time

To transmit data to a computer over the USB or serial port in real time, connect the Ozone Monitor to the USB or serial port of the computer. Plug the cable in after powering the Ozone Monitor Model 106-H to ensure correct functionality.

For the serial port connection, using the 9-pin cable provided. Note that this is a “straight-through” female-female serial cable. A “cross-over” cable will not work. The RS232 protocol is 2400, 4800 or 19200 baud as selected in the menu (see Section 3.13); 8 bits; no parity; 1 stop bit. The digital pinout for the RS232 is standard and as follows: Pin 2 = transmit, Pin 3 = receive, Pin 5 = ground. Looking at the back of the instrument, the pin numbers for the connector are:



For connection to the USB port of the computer, use either (1) the serial port of the Ozone Monitor and a serial-to-USB cable, or (2) the USB port of the Ozone Monitor and a direct USB-A-Type to-USB-B-Type cable. If using the latter option, the USB driver will automatically enable data acquisition for newer versions of the Model 106 instruments (i.e., having two relays rather than one, serial no. ≥932H) and computers running newer versions of Windows. If using earlier versions of the Model 106H and/or earlier versions of Windows, download the USB driver (<https://www.twobtech.com/downloads.html>) and follow the installation instructions that were in the manual that was included with your instrument (reproduced and updated in this manual as Appendix B).

3.12.1 Data Acquisition Software

Start your data acquisition software, preferably using the 2B Technologies Display and Graphing Software (available as a free download from the 2B Tech website at https://twobtech.com/docs/docs_software.htm). See Appendix A for a summary of working with this software. Other terminal emulation software such as HyperTerminal (a program provided with earlier versions of Windows) or [Tera Term](#) may be used as well.

3.12.2 Determine the Connection Port and Baud Rate Settings

When setting up your software or terminal emulator, choose the correct COM port listed in the Device Manager. If using Windows, go to the control panel and select System and Security > System > Device Manager. Select “Ports” to see the assigned serial or USB COM port number.

For the serial port, the baud rate setting in the data acquisition software must match the baud rate setting of the Model 106-H (2400, 4800, or 19200). Adjust the setting in the software’s setup menu and/or in the Model 106-H’s **Cfg** menu (see Section 3.13).

For the USB port, the baud rate setting in the data acquisition software must match the setting that the Model 106-H had at startup. If you wish to change the baud rate of the Model 106-H, change it in both the instrument and the software, and then reboot the instrument to begin taking data.

3.12.3 Data Output

The ozone concentration, internal cell temperature, cell pressure, reference photodiode voltage (volts), sample photodiode voltage (volts), date, and time are sent as comma-delimited ASCII text to the serial and USB ports (2400, 4800 or 19200 baud as selected in menu; 8 bits; no parity; 1 stop bit) every two seconds, ten seconds, 1 minute, 5 minutes, or 1 hour, depending on the averaging time selected from the microprocessor menu. Time is provided in 24-hour (military) format, and the date is given in European style (day/month/year). The user should separately make note of the instrument settings for units (ozone, temperature, pressure), baud rate, and averaging time.

A typical data line would read:

1.03,31.7,835.9,1.28888,0.49086,01/03/10,18:40:55

where in this example:

Ozone = 1.03 wt% O₂

Cell temperature = 31.7 °C

Cell pressure = 835.9 mbar (1 atm = 1013 mbar)

Sample Signal = 1.28888 volts

Reference Photodiode voltage = 0.49086 volts

Date = January 3, 2017

Time = 6:40:55 pm

Units for ozone, temperature, and pressure will be output as set by the user in the **Admin / Cfg / Unts** menu.

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

2893,1.03,31.7,835.9,1.28888,0.49086,03/01/17,18:40:55

where 2893 is the log number.

In addition to data lines, messages are written to the USB or 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.

See Section 3.15 below for how to access the serial menu and USB menu.

3.13 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 / Admin / Cfg / I/O / Bdr** to obtain:

Baud Menu
2400 4800 19200 ←

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

3.14 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 appropriate cable (see Section 3.12). Enable a data acquisition program on the computer such as the 2B Technologies Display and Graphing Software, which can be downloaded at:

https://twobtech.com/docs/docs_software.htm

Appendix A gives a summary of working with this display software. Alternatively, HyperTerminal can be used (provided with early versions of Windows® platforms, usually in Start/All Programs/Accessories/Communications/HyperTerminal) or Tera 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 (2400, 4800, or 19200; see Section 3.12.2); 8 bits; no parity; 1 stop bit.

Click the Select button to obtain the **Main Menu** and then the **Admin Menu**. Go to the **Dat** submenu by clicking on **Dat**. Next, click on **Xmt**. The message “Logged Data” will be written to the USB or 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.

Note that previously logged data are overwritten if logging is restarted.

3.15 Accessing the Serial Menu and the USB Menu

Measurements and logging tasks can be accessed via the serial port or the USB port using a terminal emulator such as Tera Term or HyperTerminal running on an attached computer or the 2B Technologies Display and Graphing software. Commands can be sent using the terminal emulator set with the properties listed in the section of this manual entitled “Collecting Data over the USB or Serial Port in Real Time” (Section 3.12). Listed below are the lower-case letters that are commands for performing certain operations while the instrument continues to measure:

- l** Start logging and write over existing logged data
- t** End logging and transmit logged data
- e** End logging
- h** Output serial data line header
- m** Access serial menu

If the letter **m** is sent as a command, **menu>** will be displayed in the terminal emulator window. When the serial or USB menu is accessed, the instrument is no longer making measurements; it is waiting for the next command to be entered. The following is the list of serial or USB menu items accessible from this point:

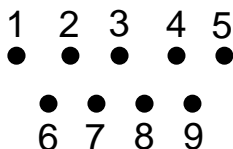
Menu Commands: Serial Port and USB Port

- l** Start logging and write over existing logged data
- t** Transmit logged data
- e** End logging
- V** Perform zero function
- h** Output serial data line header
- a** Displays list of possible averaging times and the number that must be entered to change to the desired averaging time
- z** Displays current zero calibration setting (units of vol%) and waits for new setting followed by a carriage return
- s** Displays current slope calibration setting and waits for new setting followed by a carriage return
- u** Set the zero offset for the pressure sensor
- c** Clock menu, displays current date and time and waits for **d** or **t** to be entered. From clock menu,
 - d** Asks to enter date in DDMMYY format
 - t** Asks to enter time in HHMMSS format
- Y** Set all configuration to default*
- n** Output instrument serial number
- p** Perform lamp test (Esc to exit)
- o** Change relay 2 operation for Temp, Press, PDV, PDVr
 - 1** Enable temperature inclusion for relay 2
 - !** Disable temperature inclusion for relay 2
 - 2** Enable pressure inclusion for relay 2
 - @** Disable pressure inclusion for relay 2
 - 3** Enable ref pdv inclusion for relay 2
 - #** Disable ref pdv inclusion for relay 2
 - 4** Enable pdv inclusion for relay 2
 - \$** Disable pdv inclusion for relay 2
- q** Change relay 2 operation for Ozone
- ?** Output help menu
- x** Exit menu and return to measuring

* Default settings are avg=10 s, cal slope (S) = 1, cal offset (Z) = 0, pressure sensor zero offset = 0 torr, T in °C, P in mbar, O₃ in vol%.

3.16 Collecting Data from the Analog Output

The data may be logged in real time using a data logger attached to the D9 connector on the back panel of the instrument using either a voltage or current recorder or data logger. The 0-2.5 V output is measured across pins #1 (+) and #5 (ground). The 4-20 mA current output is measured across pins #9 (+) and #5 (ground). Looking at the back of the instrument, the pin numbers for the connector are:



To change the analog output voltage scaling factor, go to **Menu / Admin / Cfg / I/O / Ext / VOUT**. The display will briefly read “VOUT Menu” followed by

2.5V=20.00 vol%
20mA=20.00 ←

In this example, the output scaling factor is set as 2.5 Volt (full scale) = 20 vol%; i.e., 1 Volt = 8 vol%. Also, the current output will be scaled such that the full scale of 20 mA corresponds to 20 vol% O₂. 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 (press in) and changing (by scrolling) 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.

3.17 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, calibrated, etc. To read the number of hours of operation choose **Menu / Admin / Cfg / I/O / Hrs**.

3.18 Using and Setting the Relay Limits

The Ozone Monitor may be used to control other devices, such as ozone generators, using two 12-amp relays located on the back of the instrument. **REL1** (the bottom relay) may be used for ozone set points, for example to set limits for high levels of ozone. **REL2** (the top relay) may be used for a second set of ozone set points (for example, in the low ozone range), or instead could be used for diagnostics such as temperature, pressure, flow rate, or lamp voltage (accessed via the serial menu, Section 3.15).

To set the On and Off ozone limits of a relay from the LCD display, choose **REL1** or **REL2** from the **Admin / Cfg / I/O / Ext** submenu. The menu will show, for example:

On =04.90 **wt% O2**
Off=05.10 ←

With these settings, the relay will close (pass current) until the ozone concentration exceeds 5.10 wt% O₂. Above this concentration, the switch relay will open. The relay will not close again until the ozone concentration drops below 4.90 wt% O₂. In this way, for example, the ozone concentration from an ozone generator could be controlled in the range 4.9 to 5.10 wt% O₂. You may now move the cursor using the Select switch to choose the digits in the On and Off relay settings: choose a digit to change by depressing the Select switch, and rotate the Select switch to change those settings. To choose another digit to change, depress the Select switch again to remove the blinking cursor. The units of the relay limits may be changed by entering the **Admin / Cfg / Unt** submenu and selecting the desired units (see Section 3.9).

Physical connection to the relay is made by means of a supplied screw connector for attaching wires to your device. The center terminal is common. When viewing the connector from the rear of the instrument, the terminal on the right is in normally open (i.e., it closes when the ozone concentration is below the first set point). This is the connection you would ordinarily use. The screw connector on the left is normally closed; i.e., it behaves in the opposite manner as the right screw terminal.

Please see our [Technical Note 45](https://twobtech.com/docs/tech_notes/TN045.pdf) for a detailed description of connecting to the relays and using them to control an ozone generator, alarms, or for creating a system override (https://twobtech.com/docs/tech_notes/TN045.pdf).

3.19 Lamp Test

If the instrument is excessively noisy (standard deviation greater than 0.02 wt%), or always reads near zero in the presence of ozone, or if the **Low Lamp** light is turned on, 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 **Admin Menu**. The display will momentarily read “**Lamp Test**”. The photodiode voltages will then be displayed, for example:

Smp=1.24578 V
Ref=0.50364 V ←

The photodiode voltages (PDV) are a measure of the lamp intensity and should be in the range 0.1-2.2 volts. Since absorbance is a ratio measurement, the absolute value of the voltages 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 voltages less than 0.1 volts without any ozone in the cell are indicative of either a weak lamp or a dirty detection cell and may result in a noisy measurement. Photodiode voltages 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. If your lamp fails the lamp test during the first year of operation, contact us for a new lamp under the instrument warranty.

3.20 LED Indicator Lights

Four indicator lights are on the left side of the front instrument panel:

- The bottom light is a Power indicator. It indicates that there is power to the instrument and that the main circuit board is working properly. The normal state is ON.
- The Low Lamp indicator comes on if the reference photodiode voltage drops below 0.1 volts, indicating that a lamp test should be conducted (Section 3.19) and that the lamp may need replacement and/or the absorption cell may need cleaning or replacement. The normal state is OFF.
- The Invalid Reading indicator is not yet operational. In a future revision, the LED will indicate when there is insufficient flow through the instrument. The normal state is OFF.
- The top light is the Cell Dirty indicator. When an auto-zero is being conducted, this light will activate if the absorption cell is too dirty (i.e., the ratio of the sample photodiode voltage to the reference photodiode voltage is less than 0.5). This status light can only be activated during the zeroing function when the cell is purged with zero gas. The normal state is OFF.

4. MAINTENANCE/TROUBLESHOOTING

The Ozone Monitor is designed to be maintenance-free. The only component with a limited lifetime is the lamp, which has a lifetime of ~20,000 hours. It is recommended that the instrument be returned to 2B Technologies if any component fails. Alternatively, the user may install components at their own risk. In that case, please contact 2B Technologies for instructions.

The 106-H has four status LEDs on the front plate to indicate any system issues that may require troubleshooting:

Cell Dirty: When an auto-zero is being conducted, this light will activate if the absorption cell is too dirty (i.e., the ratio of the sample photodiode voltage to the reference photodiode voltage is less than 0.5). This status light can only be activated during the zeroing function when the cell is purged with zero gas. The normal state is OFF.

Invalid Reading: This function is not yet operational. In a future revision, the LED will indicate when there is insufficient flow through the instrument. The normal state is OFF.

Low Lamp: The reference photodiode voltage is below 0.1 volts, indicating that the lamp intensity is low. The normal state is OFF.

Power On: Indicates that there is power to the instrument and that the main circuit board is working properly. The normal state is ON.

The following are indications of various instrument malfunctions. Refer to the labeled photos in Section 7.

Table 4.1. Troubleshooting the Ozone Monitor for performance problems.

Problem/symptom	Likely cause	Corrective action
Instrument does not turn on (Power On LED is OFF).	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.
	Power switch has become disconnected	Open instrument and push power cord back onto connector (see Fig. 7.1)
Lamp Low LED is ON.	The lamp intensity is low.	If the reference photodiode voltage is near 0.1 volts, the instrument may still function properly, but the lamp should be replaced when possible.

Cell Dirty LED is ON during the auto-zero.	Absorption cell is dirty.	Replace absorption cell, or return to 2B Tech for cell cleaning or replacement.
	Poor instrument zero.	Zero the instrument.
Display is blank or nonsense.	Bad connection of display to circuit board.	Remove top cover 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 top cover and reattach connector to circuit board (see Fig. 7.1).
Analog output is constant or does not track front display.	Cable not properly connected between analog output and recording device.	Check continuity of your analog cable to your recording device and make sure correct connector pins are being used (see Section 3.16).
	Wrong scaling factor selected In menu.	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.	Remove top cover 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.	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.
	Wrong baud rate selected.	Make sure that the baud rate chosen in the menu matches the baud rate setting of your data acquisition program.

<i>Required calibration parameters are large ($>\pm 15\%$ slope) when calibrated using a reliable ozone instrument.</i>	Flow path is contaminated.	Replace the absorption cell, or return instrument to 2B Technologies for cleaning or replacement of the absorption cell.
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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 and calibration against an IOA-traceable standard. The best way to contact us for service is to log a customer service ticket at <https://twobtech.com/tech-support.html>. 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 https://www.twobtech.com/docs/docs_tech_notes.htm. Manuals, brochures, software, cleaning procedures and scientific papers may be downloaded at <https://www.twobtech.com/downloads.html>.

5. CALIBRATION

Every analytical instrument is subject to some drift and variation in response, making it necessary to periodically check the calibration. Since the reliability of the data collected from any analytical instrument depends on the accuracy of the calibration, it is necessary to calibrate the instrument against a recognized standard such as the International Ozone Association (IOA) KI method. This method is detailed in the Iodometric Method for the Determination of Ozone in a Process Gas, Revised Standardized Procedure 001/96 (KI Method) established by members of the Quality Assurance committees of the International Ozone Association (IOA), including the Pan American Group (PAG), European African Group (EAG) and Nippon Islands Group (NIG). This procedure is an expanded version of the IOA method described in: Rakness, K., et al., Guideline for Measurement of Ozone Concentration in the Process Gas from an Ozone Generator, *Ozone Science and Engineering* **18**, 209-229 (1996). It should be noted that there is no method directly traceable to NIST for ozone concentrations above 1 ppm.

5.1 Equipment Required

For routine calibration, an instrument can be calibrated against a working ozone standard, which is an ozone monitor that has been calibrated against the IOA KI method. The equipment that is needed to carry out the calibration is commercially available. Calibration using a working ozone standard involves the generation of ozone concentrations that are simultaneously measured by the working standard and the instrument undergoing calibration. This procedure requires the following equipment:

1. Zero gas source
2. Ozone generator
3. Sampling manifold (inert material such as PTFE or FEP only)
4. Sampling lines (inert materials such as PTFE or FEP only)
5. Ozone monitor calibrated against the IOA KI Method

5.2 Calibration Procedure

A multipoint calibration should be performed within the calibration frequency, any time major disassembly of components is performed, or any time the span checks give results outside of the acceptable limits.

5.2.1 Instrument Preparation

1. Turn on the Model 106-H Ozone Monitor and allow it to stabilize for a minimum of one hour.
2. Allow the working standard to warm up according to the instrument user manual.
3. Enter the calibration menu (Main Menu / Admin / Cfg / Cal / O3) and set the zero (Z) value to 0.00 and the slope (S) value to 1.000.
4. Connect the ozone monitor to the manifold of the ozone calibration setup.

5.2.2 *Measurement of Zero Gas*

1. Verify that the zero gas supply is on and the ozone generator is off. The same zero gas supply used in the ozone generator must be used in the zero gas measurement.
2. Allow the Model 106-H to sample zero gas until the response is stable.
3. Perform the zero function in the menu (Section 3.10).

5.2.3 *Measurement of Ozone Standards*

1. Generate an ozone concentration slightly less than the concentration range of interest and allow the ozone generator to warm up for at least 5 minutes. The same zero gas supply used for making zero gas measurements must be used in the ozone generator.
2. Allow the Model 106-H Ozone Monitor to sample the ozone concentration standard until a stable response is measured.
3. Record the average response of the ozone monitor as well as the average response of the working standard.
4. Generate several other ozone concentration standards. At least 5 ozone concentration standards are recommended over the range of interest.
5. For each ozone concentration standard, record the response of the ozone monitor as well as the working standard.

5.2.4 *Calibration Curve*

1. Plot the Model 106-H Monitor responses (y-axis) versus the corresponding standard ozone concentrations (x-axis).
2. Fit the data to a straight line ($y = mx + b$) using the linear regression technique to determine the calibration relationships.
3. Determine if any points deviate significantly from the line, which is an indication of an error in determining the calibration curve. The error may be due to the calibration setup or the ozone monitor being calibrated.
4. The inverse of the slope of the line ($1/m$) is the gain factor (S) that needs to be applied to the ozone monitor response to calibrate it to the working standard. If the slope is outside of the range from 0.850 to 1.150, this is an indication of a problem in the calibration setup or the ozone monitor being calibrated.
5. Enter the calibration menu (**Main Menu / Admin / Cfg / Cal / O3**) in the instrument software and set the S calibration parameter ($1/m$ as determined above).

6. PERIODIC ZERO AND SPAN CHECKS

To ensure the quality of the ozone monitor data, periodic zero and span checks can be performed by following the steps below:

1. A zero check is performed by sampling zero gas following the "Measurement of Zero Gas" Section 5.2.2 above.
2. A span check is performed by sampling an ozone concentration at the high end of the concentration range of interest following the "Measurement of Ozone Standards" Section 5.2.3 above.
3. Average measurements from the zero check or span check should be within the instrument specifications. If the measurements are not within specifications, this is an indication of problem in the calibration setup or the ozone monitor being checked.

7. LABELED INSTRUMENT PHOTOS

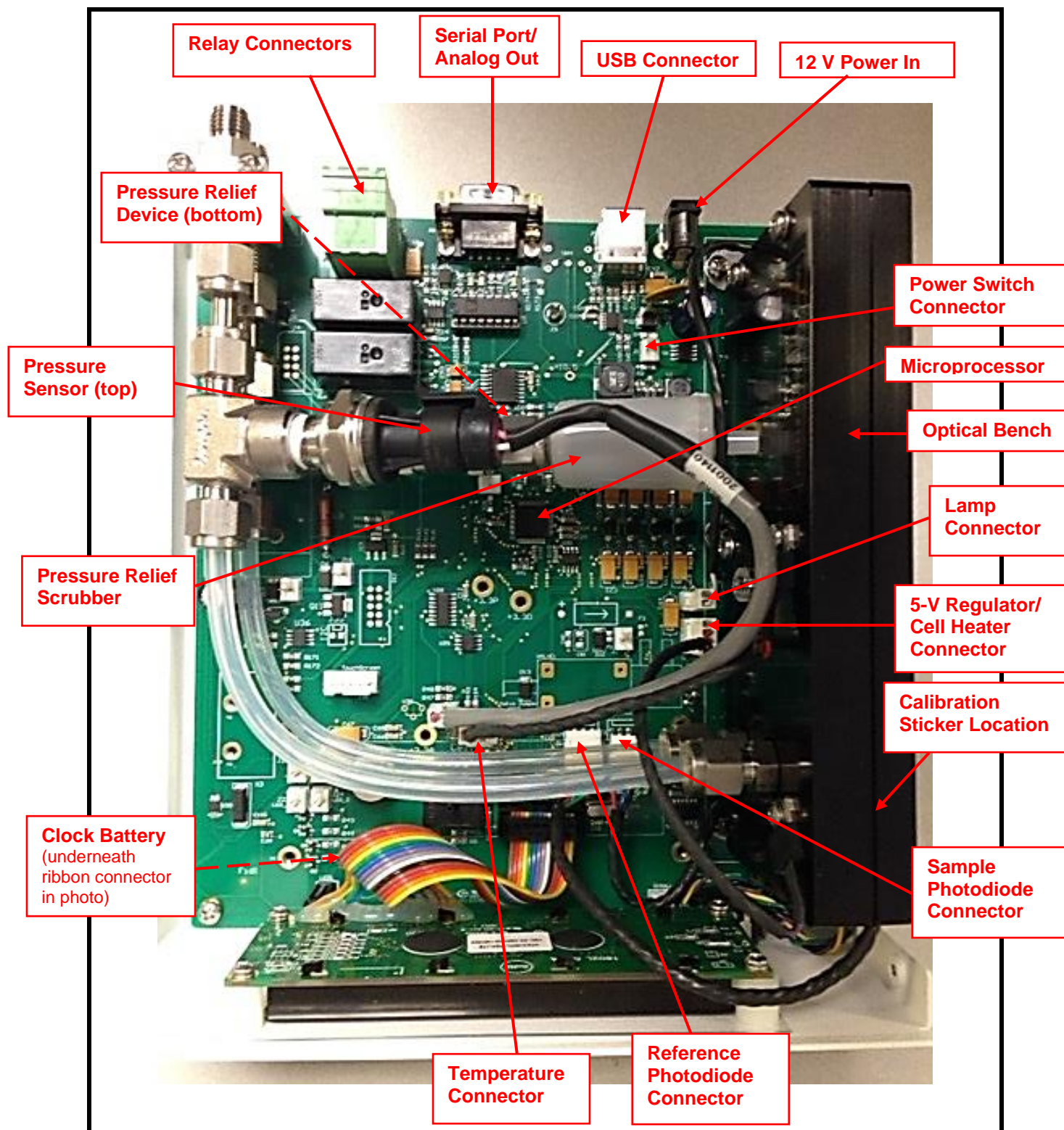


Figure 7.1. Standard Version of the Model 106-H.

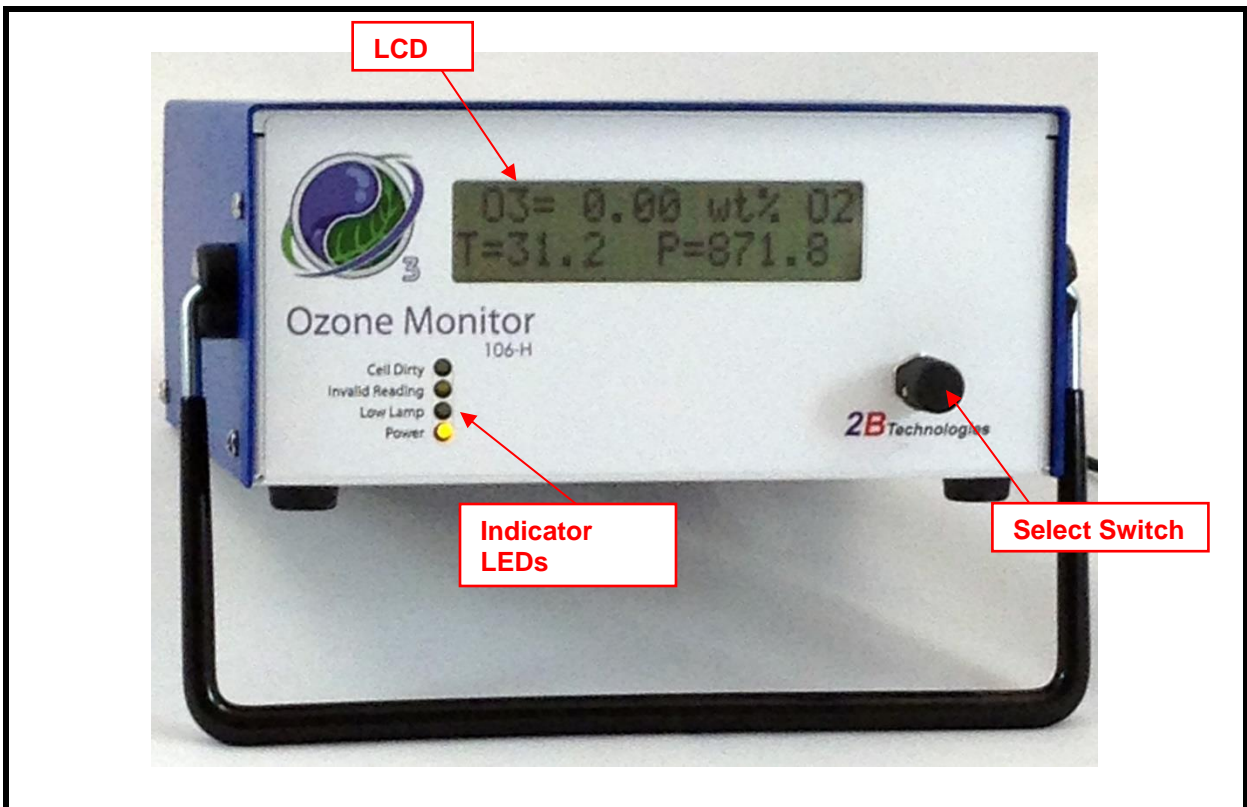


Figure 7.2. Front Plate of the Model 106-H.

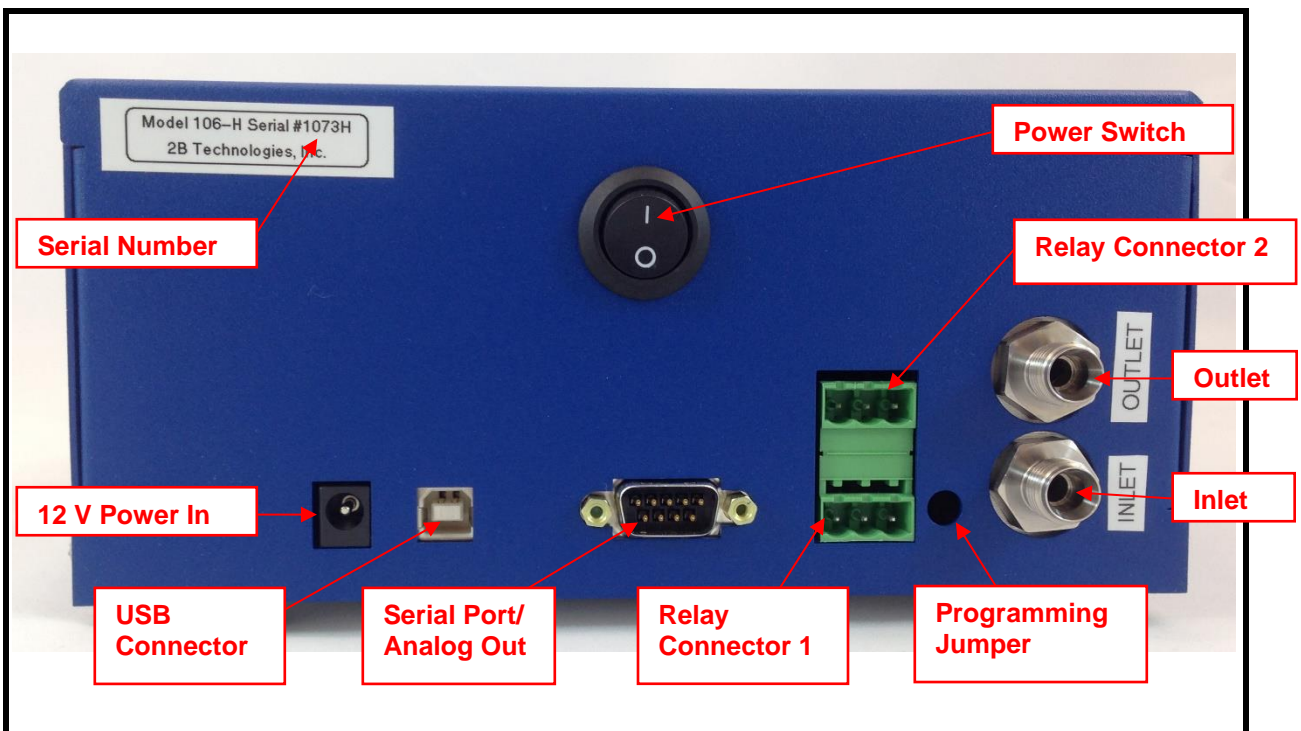


Figure 7.3. Back Panel of the Model 106-H.

8. REPLACEMENT PARTS

The following list includes those parts of the Model 106-H Ozone Monitor that are user serviceable.

Please see the 2B Technologies website for a full and updated list of parts and pricing: <https://twobtech.com/parts-online.html>

Part #	Part Number	Description
11-065	OZLAMPAS106H	Lamp assembly
10-565	OZDSP106	LCD display and cable
10-699	PDASSEMBLY106	Photodiode assembly and cable
10-586	OZCELL106H	Absorption cell assembly
10-575	SELECTSWITCH106	Select switch
10-086	RELCON	Relay connector
11-146	RS232BRKOUT	RS232 breakout connector
10-025	SERCABL	Serial port cable (to computer)
10-030	USBCABLE	USB Cable (USB-A to USB-B 2.0 cable)

9. SERVICE LOG

2B Tech Instrument Model #: _____

Serial #:_____

[illegible]

Appendix A: Using the 2B Technologies Display and Graphing Software

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Introduction

2B Data Display® is an easy way to display and save data from your serial or USB connection.

With easy one-click operations, data are read from your instrument and displayed on an extremely versatile chart. Two items, such as Ozone and Temperature, can be displayed simultaneously on the chart with multiple zoom levels. Data are automatically saved to a .txt file and can optionally be saved to a .CSV file to be read in Excel. Saved data can be restored for later viewing and analyzing on the chart. By requesting an account with 2B Technologies, you can upload your data and view it on a Google Earth overlay.

Video Tutorial

A video tutorial on using 2B Data Display may be found on our website. Go to the “Software” tab of the following link: <https://twobtech.com/videos.html>

Downloading the Software

Go to <https://www.twobtech.com/downloads.html> and select the Software tab. Click the link for “2B Tech Display and Download Software.” Follow the instructions, doing the two installations if needed and choosing to save the “setup.exe” file. Double-click the setup.exe download to launch the 2B Data Display application.

Connecting Devices

Connect to an Ozone Monitor

1. Select the device you are connecting to from Settings: Select Device (use 106-H setting).
2. Click OK.
3. Select the Connection you will be using from Settings: Connection
Choose the settings as follows:
 - a) Port:
 - The default port is “COM1” for computers with a serial port.
 - If using a USB connection, check for the correct port in the “Device Manager” under “Ports” located in: Control Panel : System : Device Manager.

- If using a USB to Serial adapter, check for the correct port the same as for a USB connection and look for the name of the adapter (e.g., Belkin, Prolific, or other USB to Serial adapter manufacturers).
 - b) Baud Rate: The Default baud rate is 2400. Check your Ozone Monitor's settings in the "Cfg / I/O" menu and match the software with the monitor's setting. Note that for the USB port, the baud rate must match the baud rate of the Ozone Monitor at the Monitor's startup.
 - c) Parity: None
 - d) Data Bits: 8
 - e) Stop Bits: One
4. Click Start button in the Instrument Data Capture section in the upper left corner of the main screen.
- a) The "Save As" window will appear. A default file name will appear which is made of the date and time. You may change the filename and change where it is saved if you wish.
 - b) Click the "Save" button. This will start the data capture software and data will fill into the chart as they are transmitted from the device.
 - c) The red OFF text will change to green ON text. The text: Waiting for data... will appear until data arrives from the instrument. If the instrument measurement frequency is set to 2 seconds, you will see a data point every 2 seconds. Averaging frequencies can be set to 10 seconds, 1 minute, 5 minutes, and 1 hour in the Avg submenu on the instrument.

Connect to Weather Station (Davis Vantage Pro)

1. Be sure the weather station is physically connected to the USB port or Serial port of the computer.
2. Select the COM port for the weather station from *Settings : Weather Connection Settings...*
3. Select "Retrieve Weather Data" from the "Weather Link" menu. A window will appear and the software will try to retrieve the weather station data. If the connection is good, weather data will be displayed in the window. If not, an error message will appear. Try a different com port if the error message appears. You may move this window so it is out of the way or you may close it. The weather data is updated every 5 seconds.
 - Since the Ozone Monitor and the Weather Station both use COM ports, you may have to unplug one of the USB adapters from the PC to determine which device is using which COM port.
4. To bring up the window again if you have closed it, select "Display Weather Data."

Viewing Data

The Data Grid Tab

1. Make sure the application is connected to a device or that you have opened a previously saved data file.
2. Click the *Data Grid* tab on the right side of the screen.
3. The data lines received from your instrument will be listed in a grid with the latest point at the top.
4. The header contains the device specific variables (e.g., Ozone, Cell Temp...). Log Number is always listed even if your instrument is not set to log.

The Charts Tab

1. Make sure the application is connected to a device or you have opened a previously saved data file.
2. Click the *Charts* tab on the right side of the screen.
3. Select which data items to display from the drop down windows “Data 1” and “Data 2.”
4. The data points will appear in a graph window in the middle of the screen.
5. Adjust the zoom level by pressing the + or – buttons under the *Settings* button (upper right side of screen).
6. Adjust the Y scale or set the *Auto Range* feature by pressing the *Settings* button
 - a. Check the *Auto Range* box to use autoscaling.
 - b. Uncheck the *Auto Range* box to manually set Y max and Y min for the Data 1 and Data 2 fields.

The Buffer Tab

- Selecting the Buffer tab brings up a buffer window, similar to Tera Term or HyperTerminal, where all data from the serial port are displayed.
- From this tab, the user can also send commands through the serial port by typing on the keyboard. This is only applicable if the device that is connected accepts serial commands. See the instrument manual for a list of the serial commands.
- This buffer window can also be used for troubleshooting for instances when: the baud rate, device, or serial port is unknown. For example, if the status bar in the “Instrument Data Capture area states “Receiving...” and no data appear in the Data Grid or the Charts, click on the Buffer tab to view the serial data. If the correct device is not selected, no data will be displayed in the Data Grid or the Charts, but data will be displayed in the Buffer window.

Saving Data

Saving Ozone Data to a .txt File

1. Click the *Start* button in the Instrument Data Section to begin collecting data from the instrument.
2. A window will pop up to prompt for the name and location of the file.

3. Click Save to begin the data collection.
4. All data read from the ozone monitor through the COM port are written to the .txt file in real time until *Stop* is clicked.

Saving Data to a .CSV or an Excel File

NOTE: Weather data are NOT saved to the .txt file. In order to save weather data, be sure to save a .CSV file after *Stop* is clicked.

1. After collecting data, click the *Stop* button in the Instrument Data Capture Section on the main screen.
2. A window will pop up to ask you if you would like to save to a CSV file as well. Click Yes.
3. A default name appears from the date and time of the data capture. You may change the name and path of the file if you wish.
4. Click on the Save button.

Opening Files

1. To open a file, click *Open* from the *File* menu.
2. Navigate to the folder where the file was stored.
3. Select either the .txt file or the excel file and press *Open*.
 1. NOTE: To view weather data, you must open the corresponding .CSV file.
4. Choose the correct device associated with the file.
 - a. If you are unsure, open the file in a text editor or Excel to determine which device.

Serial and USB Commands

The menu commands are the same as given in Section 3.15 of this manual.

Appendix B: Installation and Use of the USB Connection (for older versions of the Model 106 and/or Windows)

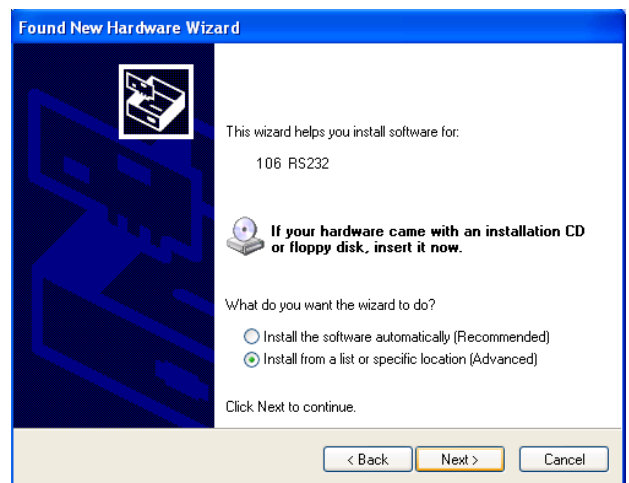
The following procedure describes how to install and use the USB connection for earlier versions of the Model 106-H (those having 1 relay rather than 2 relays) and/or for PC computers running earlier versions of Windows.

Items Required

- USB-A Type to USB-B-Type Cable
- Model 106-H Ozone Monitor (older version, 1 relay) **and/or**
- PC Computer with Windows 2000, XP, Vista, or earlier

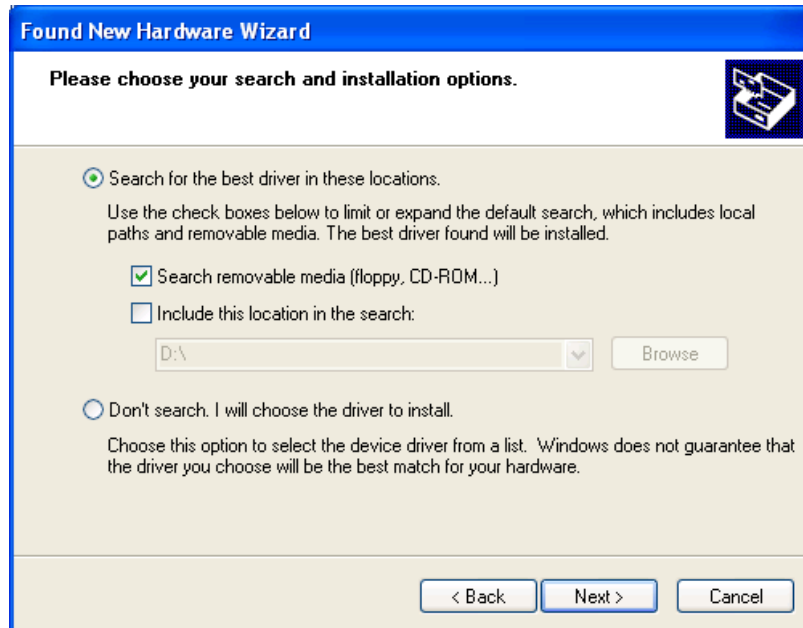
Driver Installation

1. Download the 106 USB driver from 2B Tech's website, <https://www.twobtech.com/downloads.html>
2. Navigate to the folder labeled "cdc_NTXP" and double click on it.
3. Unzip the contents to a folder on the desktop or any area you wish.
4. With the Model 106 off, attach the USB cable from the Model 106 to a USB port on the computer.
5. Turn on Model 106. The install wizard should pop up as follows. Select "No, not this time" and click "Next".



6. In the new popup window, select the "Install from a specific location" option and click "Next".

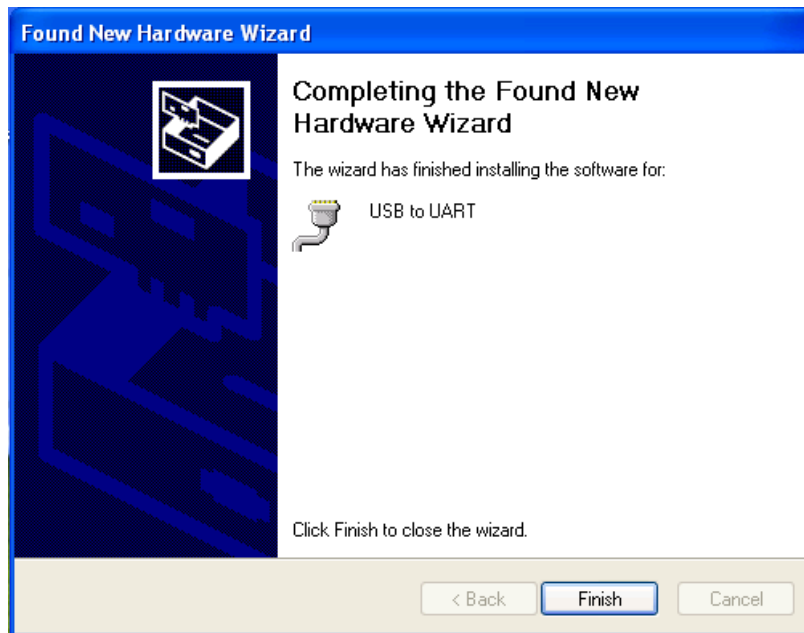
7. Navigate to folder where you unzipped the cdc_NTXP.



8. Select "Continue Anyway" when this window appears.



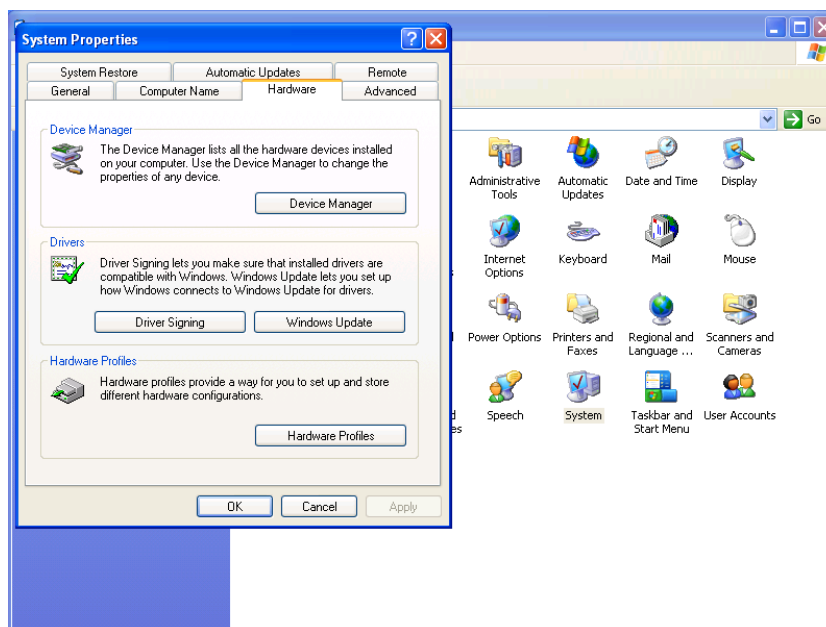
9. After a few seconds, the driver will be finished installing.



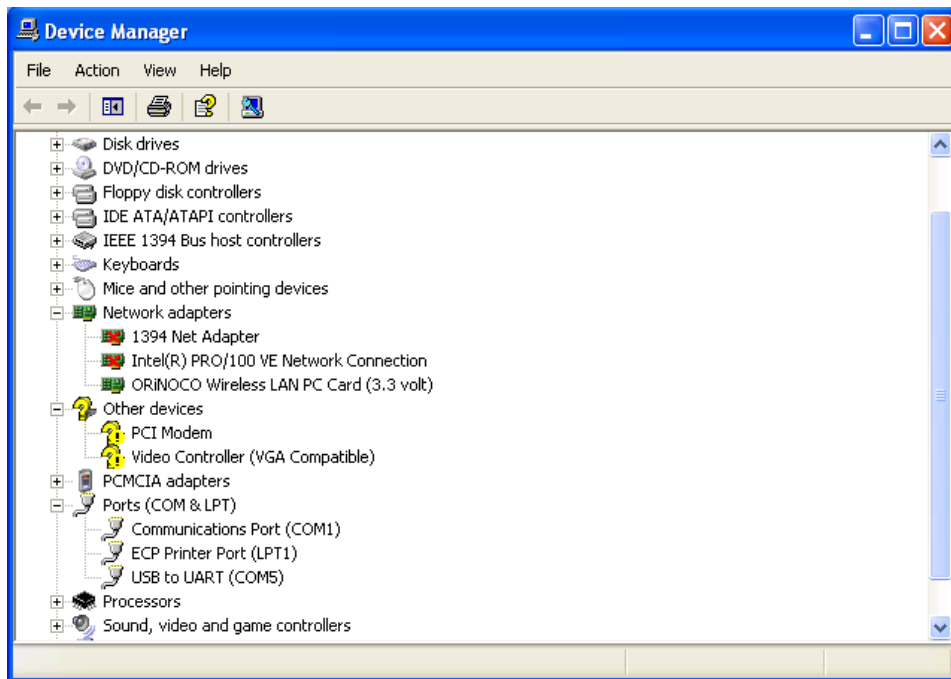
Determine the Connection Port

After installation is complete, determine which COM port the connection is using. This can be done by the following procedure.

1. If using Windows (XP,Vista,7), go to the control panel and select “System.”
2. Click on the “Hardware” tab.



3. Click the “Device Manager” button.
4. Press the “+” sign next to “Ports”.



5. In Parenthesis, next to the “USB to UART” listing is the assigned COM port number. This number will be used for the settings for the Terminal emulator or software used to read data from the Model 106.

Using the Connection

- Plug the USB cable in after the powering the Model 106 to ensure correct functionality.
- When setting up your software or terminal emulator, choose the correct com port listed in the Device manager.
- Use these baud rate settings: 2400, 8 bits; no parity; 1 stop bit.
- Use 2B Technologies Display and Graphing Software (free download from https://twobtech.com/docs/docs_software.htm) or other software (such as HyperTerminal or [Tera Term](#)) to read measurement data from the Model 106.

Appendix C: Mounting the OEM Model 106 Ozone Monitor

The circuit board has four holes for mounting the ozone monitor to standoffs below the instrument (Figure C-1). The holes are for #6 machine size screws. Use insulating screws and washers to mount the instrument if mounting to something that is not grounded, otherwise use stainless steel screws and washers for three of the holes, and a plastic washer for the hole by the select switch (see below).

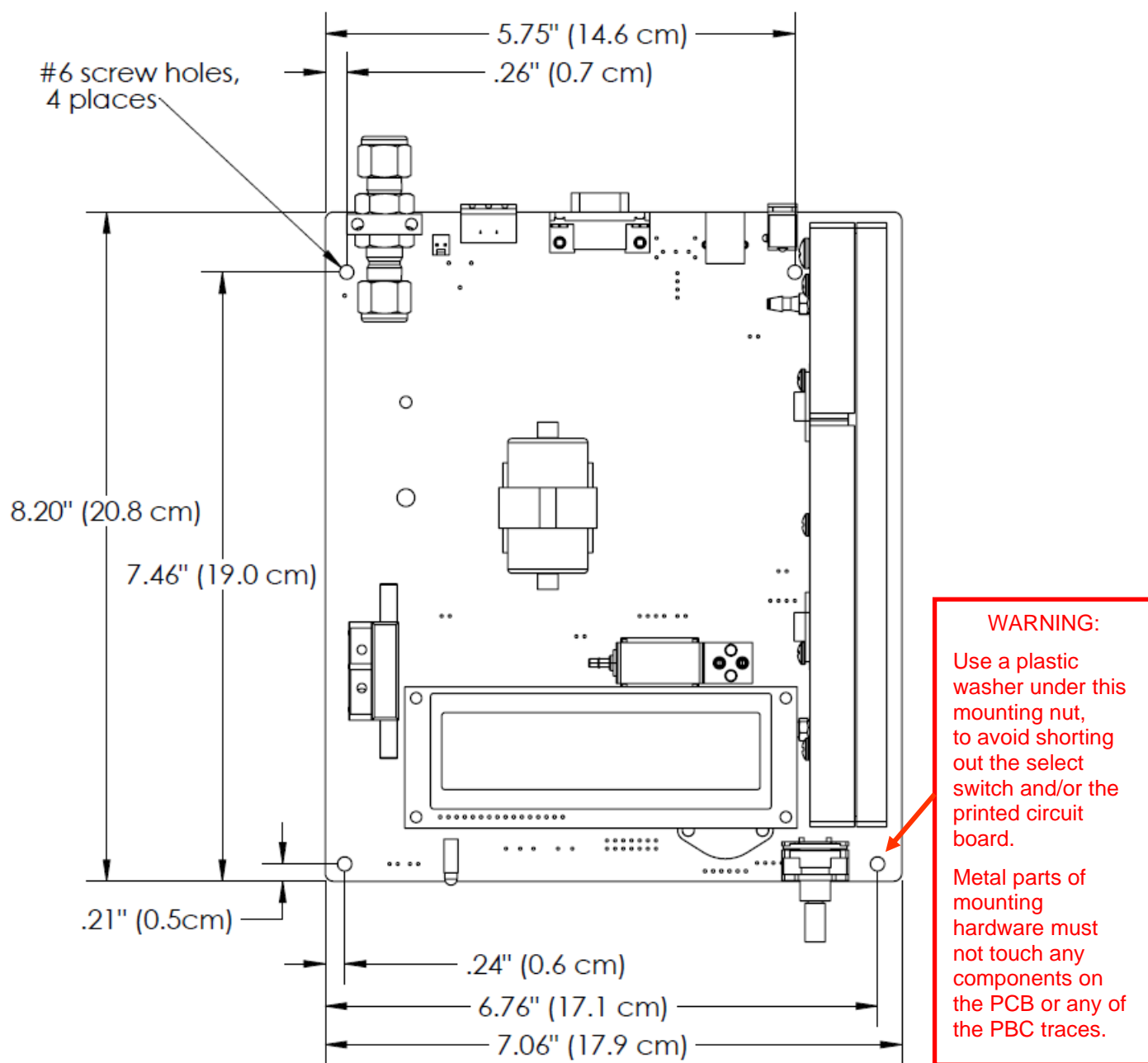


Figure C-1. OEM Dimensions and Mounting Holes (Top View).