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STATEWIDE STANDARD OPERATING PROCEDURE FOR 2B TECHNOLOGIES MODEL 211 OZONE MONITOR

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTON
OFFICE OF MONITORING

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EPA Region IV Approval Officer

Revision No.	Date	Responsible Person	Description of Change
0	12-2020	Jeff Anthony	Initial PNRD SOP

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1.0. Purpose

This document has been prepared for operator use during routine, periodic and calibration procedures at Florida ambient air monitoring stations utilizing a 2B Technologies Model 211 Ozone Monitor (Model 211).

Note: The principle of operation of the 2B Technologies Model 211 Ozone Monitor is described in Section 1, *Ozone Monitor Introduction*, on page 1 of the manufacturer's manual.

The Model 211 is typically installed in a temperature- and humidity-controlled shelter. Ambient air is sampled through a single-line inlet to the instrument. The standard ozone monitoring system also includes a Thermo Scientific Model 49i-PS Primary Standard or similar instrument to calibrate the Model 211 and a data logger (Logger) to record ozone observations.

Note: Some portions of this SOP may not be suitable for operations employing different ancillary components.

These procedures are based on requirements contained in the manual supplied by the manufacturer with the Model 211, Parts 50, 53, and 58 of the Code of Federal Regulations, and the Florida DEP Quality Assurance Project Plan.

2.0. Scope and Applicability

This document was developed to establish a specific Standard Operating Procedure (SOP) for ambient air quality monitoring using the 2B Technologies Model 211 ozone monitor (Model 211) at Florida air quality monitoring stations. It is based primarily on the Model 211 operation manual, the requirements set forth in the Code of Federal Regulations regarding ambient air quality monitoring, companion SOPs of the Florida PQAO and the Florida Department of Environmental Protection (FDEP) Quality Assurance Project Plan (QAPP) for ambient air quality monitoring (see Section 12.0, *References*). The procedures described herein additionally reflect the practices of Florida air quality monitoring entities where they do not conflict with the aforementioned references.

The Model 211 is a compact, lightweight (14.7 lb/ 2.1 kg) and low-power (12 W) instrument designed for continuous measurement of the ambient concentrations of the criteria air pollutant ozone (0_3) gas (14.6, *2B Tech. Model 211 O_3 Monitor Front Panel;* 14.7, *2B Tech. Model 211 O_3 Monitor Rear Panel*). The Model 211 is suitable for a variety of remote monitoring activities and examples have been deployed in the Antarctic, in the desert, on oceanic buoys, and launched on high –altitude balloons. When combined with an ozone primary standard and ancillary equipment in a suitable shelter the instrument forms the core of a complete monitoring system for ground level ozone (14.9, *Station Layout*).

3.0. Summary of the Method

Ozone (O_3) is the triatomic form of the common oxygen (O_2) molecule. Ozone gas concentrations in ambient air may be conveniently measured using the adsorption of ultraviolet (UV) light at 254 nm wavelength. The Model 211 is fundamentally a calibrated UV photometer. Stable, accurate ozone concentration measurements ultimately depend upon the quality of the photometer calibration. Calibrations are performed with a separate instrument such as a Thermo Scientific 49i-PS primary standard

The ozone molecule has an absorption maximum at 254 nm, coincident with the principal emission wavelength of a low-pressure mercury lamp. Few molecules found at significant concentrations in the atmosphere absorb at this wavelength. However, UV-absorbing organic compounds containing aromatic rings (benzene, toluene, xylene, etc.), can occur in highly polluted air and provide an interference of up to several ppb. Indoor air can contain a wide variety of UV-absorbing compounds due to outgassing of polymeric materials such as carpet, furniture, and insulation. Because ozone monitors use a Hg vapor lamp as an excitation source, mercury is detected with about 1,000 times more sensitivity than is ozone. In other words, 1 part-per-trillion of Hg can produce a signal equivalent to about 1 ppb of ozone. UV-absorbing compounds are present in many industrial settings as well. Because of these potential interferences, The scrubberless ozone monitor is designed to provide a very high degree of selectivity against all UV-absorbing compounds other than ozone. The interference problem in conventional ozone monitors can be traced to the ozone scrubber. UV absorbing compounds that adsorb on the solid-phase scrubber and are removed from the sample air in the “reference” measurement are erroneously measured as ozone. The Model 211 Scrubberless Ozone Monitor uses a gas-phase scrubber technology that quantitatively removes ozone from the sample and does not remove UV-absorbing compounds. Since the potentially interfering compounds are present at the same concentrations in the “reference” and “sample” measurement steps, their contribution to the measured light absorption is cancelled out and they are not measured as ozone. The gas-phase scrubber technology is based on the quantitative reaction of nitric oxide (NO) with ozone (O3):

Note: New operators should familiarize themselves with the instruction manual for the Model 211 and this SOP document before going any further.

4.0. Definitions and Conversion Factors

4.1. Definitions

Accuracy. The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (imprecision) and systematic error (bias) components which are due to sampling and analytical operations.

Audit Device. A calibrated instrument or tool used to align, adjust or calibrate other components of the ambient ozone measurement system.

Bias. The systematic or persistent distortion of a measurement process which causes errors in one direction.

Calibration. Calibration is the process employed to verify and rectify an instrument's measurements in order to minimize deviation from a standard. Calibration requirements for critical equipment are found in the Florida PQAO SOPs and in the specific instruments' operations manuals.

FAMAS. An acronym for the Florida Air Monitoring and Assessment System. FAMAS is a web-based database management system for the State's ambient air quality monitoring data.

Precision. A measurement of mutual agreement among individual measurements of the same property usually under prescribed similar conditions, expressed generally in terms of the standard deviation.

Precision Check. The implementation of the one-point quality assurance check for ambient ozone automated analyzers described in 40 CFR Pt. 58, Appendix A. This check is conducted at a minimum bi-weekly frequency using an ozone concentration within the range of 5 ppb to 80ppb. The precision concentration used by Florida SOPs for ozone monitors is 70 ppb. This check is normally conducted at the same time as a zero and span check.

PQAO. An acronym for Primary Quality Assurance Organization, a group of monitoring organizations operating under a common quality control framework as described in 40 CFR Pt. 58, App. A. The Florida PQAO is one example.

Sample Line Integrity Check (SLIC). A demonstration that the ambient air sample line, sample inlet filter, and ancillary hardware are not destroying ozone (e.g. dirty sample line) or are affecting sampling (e.g. clogged sample filter). This check is conducted at "span" gas concentration used in the zero and span check. Quarterly SLICs are required. However, this check is normally conducted every time a zero and span check is conducted.

Scrubberless. Does not contain a conventional solid-phase ozone scrubber. Instead, nitric oxide is used in the gas phase to remove or "scrub" ozone.

Zero and Span Check. An implementation of the instrument functionality and calibration demonstration for ambient ozone automated analyzers described in the US EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. II. This two-point check is conducted at a minimum frequency of bi-weekly using ozone concentrations of 0 ppb (zero air) and a "span" concentration derived from: a) selection of an appropriate calibration scale and b) selecting a span concentration greater than 120% the highest NAAQS ozone value and greater than 99% of the ambient ozone observations over a 3 year period. Florida SOPs for ozone primary standards use a span concentration of 250 ppb, based upon a 300 ppb operating range. Zero and span checks are normally conducted at the same time as a precision check.

Zero Air. Clean, dry air free of ozone and any substance that can react with ozone (e.g. NOx, hydrocarbons and particulates).

4.2. Conversion Factors

The following conversion factors or formulas may be needed:

Barometric pressure. To convert barometric pressure in milli Bar (mb) to millimeters of Mercury (mm Hg, at 0 deg. C) use:

$$\text{Value in mm Hg} = \text{Value in mb X } 0.75006 \text{ mb / mm Hg} \tag{1}$$

5.0. Health and Safety Precautions

Ordinary hand tools and basic electrical testing equipment are required for the installation and adjustment tasks described in this SOP. Operators should employ basic shop-safety practices such as the using the correct tool for the task, wearing of eye protection and keeping the work area clean and organized. Use cutting tools carefully. Electrostatic discharge protection practices, such as the use of an antistatic wrist strap, are required when working on electronic components or circuit boards.

Note: An antistatic wrist strap does not protect the wearer from electrical shock hazards.

Operators may be required to make internal adjustments to an instrument while it is operating. Most instruments are powered from the electrical mains. Be aware of electrical shock risks, including those posed by items falling into an operating instrument. Avoid contact with heated or moving components such as fans. Do not look directly at the ultraviolet (UV) light source in photometers.

Work on the instrument shelter and site may require the use of power tools, work on elevated platforms or ladders, or the use of chemicals, paints or sealers. Operators should be familiar with all aspects of the task at hand including how to secure a safe work area. Read both the instruction and caution labels on all chemicals. Suspend work on or around the site's meteorological tower or lightning protection system if an electrical storm threatens. Any construction waste generated should be properly disposed.

The Model 211 uses Nitrous Oxide (N2O) as a reagent gas and operator must familiarize themselves with the Safety Data Sheet (SDS) before operating the instrument.

Ozone primary standards can generate significant volumes of ozone gas at potentially harmful concentrations. Operators should familiarize themselves with the odor of ozone gas so they are alerted to potential problems. Ozone should be discernible by smell at concentrations above about 20-50 ppb. Exhaust or waste gas lines from the calibration process should either be passed through a carbon cartridge or vented outside the shelter. A current Safety Data Sheet (SDS) for ozone is posted at all monitoring stations.

Note: High concentrations of both Ozone and Nitrous Oxide have health safety concerns. Nitrous Oxide is an oxidizer and may ignite or explode on contact with combustible materials.

6.0. Personnel Qualifications

Personnel who operate instruments used for the ambient monitoring of ozone within the State of Florida are typically selected for their position based on applying for the position and demonstrating they have the required knowledge, skills, and abilities to perform the essential elements of the position.

Program management will devise an individualized course of training for new operators using such tools as internal training programs, external training programs, and apprenticeships with experienced operators. The latest version of each Florida PQAO SOP along with the accompanying manufacturer documentation forms the corpus of the training materials.

New operators may not have all of the practical skills (e.g. soldering) needed to perform all the tasks in this SOP. Program management will arrange for personalized training to fill any individual deficiencies

7.0. Equipment and Supplies

All of the equipment described in this section are enclosed in a temperature- and humidity-controlled monitoring shelter. One or more ambient air sampling lines extending into the shelter from the exterior provides a path for ambient air to reach measurement instruments. Various types of shelter environmental sensors, communication equipment and power protection devices will also be present.

7.1. Requirements for Normal Operation

The following instruments, equipment and supplies are required for an operating installation of a 2B Technologies Model 211 Ozone Monitor (Model 211) at a Florida ambient air quality monitoring station. This list includes equipment and supplies needed for basic functional checks:

1. *Zero Air Supply*. A zero air supply is required to provide the companion ozone primary standard (calibrator) with a source of dry, pollutant-free reference air at a constant pressure and predictable delivery rate. There are a number of configurations in current use throughout Florida.

   Note: Ensure that scheduled maintenance has been performed before use.

2. *Data Logger (Logger)*. An Environmental Systems/Agilaire Model 8872 Data Acquisition System (DAS) (Model 8872 DAS or Logger) used to aggregates monitoring data and run calibration programs. Sophisticated versions are complete computers, in themselves. Data are periodically retrieved from loggers by central database software such as Agilaire's AirVision.

   Note: Ensure that scheduled maintenance has been performed before use.

   Note: Data logger configuration and interfacing are beyond the scope of this SOP.

3. *Computer*. A computer or tablet with file storage capable of communicating with the data logger. The computer may be portable, located remotely (accessing the data logger via the Internet), or the on-board computer of an Agilaire 8872 DAS. The computer is used for electronic documentation of calibrations, checks, maintenance, and other operations.

4. *Ozone Primary Standard (Calibrator)*. The ozone primary standard is used to calibrate and verify the correct operation of the Model 211. This instrument must be re-certified annually by a traceable process. There are a number of monitor makes and models in current use throughout Florida.

   Note: Ensure that the calibrator certification is current.

5. *Nitrous Oxide (N2O).* A tank of medical grade, 95% or higher Nitrous oxide. Safety measures must be considered when securing tank with proper equipment. A regulator set to no more than 20 PSI and proper fittings and Teflon tubing for interconnection requirements.

6. *Sample Line Inlet Filter*. The gas pathway inside the ozone monitor is protected by a PFTE Teflon® membrane filter, 5 um pore size, that is 47 mm in diameter (Millipore Mitex Type LF or similar). The filter is enclosed in a PFTE Teflon® filter holder inserted into the sample line just outside the back of the monitor.

   Note: Ensure that the sample line inlet filter has been replaced on schedule.

7. *Teflon® SLIC Line (SLIC Line)*. A length of clean ¼" OD by 3/16" ID "thin wall" FEP Teflon® tubing long enough to reach from the calibrator outlet to the input of the Model 211. This line should have appropriate PFTE Teflon® ¼" Swagelok tubing connectors preinstalled to mate with each instrument. A "T" fitting is provided at the monitor end to provide a point to vent excess calibrator gases outside the shelter at ambient atmospheric pressure.

   Note: Build one SLIC line for each monitoring station and store this apparatus at the station.

   Note: Keep the ends of the SLIC line capped between uses. Discard and replace the SLIC line annually.

   Note: During SLIC checks, the exhaust vent mentioned should be connected to a length of tubing sufficient to lead it outside the monitoring shelter or through a charcoal cartridge to prevent ozone buildup inside the shelter.

8. *Additional Teflon® Sample Line and Fittings*. Have available several lengths of clean of FEP Teflon® tubing and some PFTE Teflon® ¼" Swagelok tubing connectors and a selection of other ¼" NPT and tubing hardware to interconnect instruments and form exhaust lines or vent caps.
9. *Basic Hand Tools*. For example: Screwdrivers, pliers (standard and needle-nose), adjustable wrenches, Allen wrenches, utility knife, and a wire stripper. This list should be supplemented with some specialty items: Sample line filter handling forceps, manufacturer's wrench set for opening the sample line filter housing.
10. *Consumables and Spare Parts*. As needed.
11. *Forms*. As needed.

7.2. <u>Additional Requirements for Setup and Maintenance</u>

The following additional equipment and supplies are required to setup and configure a new Model 211 and complete annual preventative maintenance:

1. *Digital Thermometer*. A calibrated electronic digital thermometer with a contact-type thermocouple probe is necessary to verify the optical bench temperature sensor in the Model 211. Refer to the manufacturer's manual for specific operating instructions for this instrument. Various makes and models may be used at Florida ambient air monitoring stations.

   Note: Ensure that the calibration of this audit device is current before use.

2. *Precision Barometer*. A calibrated non-liquid precision barometer is necessary to verify the optical bench pressure sensor. Refer to the manufacturer's manual for specific operating instructions for this instrument. Various makes and models may be used at Florida ambient air monitoring stations.

   Note: The units of measurement for barometric pressure used by the barometer are likely to be different from the units of measurement for bench pressure reported by the Model 211.

Note: Ensure that the calibration of this audit device is current before use.

3. *Primary Flow Meter*. A calibrated Bios International Corporation DryCal DC-2 Definer 220 Series primary flow measurement device is required to verify the flow sensors in the Model 211. Refer to the manufacturer's manual for specific operating instructions for this instrument.

   Note: This instrument is sensitive to vibration and electrical noise. It should be isolated from bench top vibration (a neoprene mouse pad will work) and operated from its internal batteries.

   Note: The 2 um inline filter provided should always be used on the input side of the instrument.

   Note: Ensure that the calibration of this audit device is current before use.

4. *Basic Hand Tools*. As needed.
5. *Consumables and Spare Parts*. As needed.
6. *Forms*. As needed.

The following equipment are optional:

7. *Digital Voltmeter*. A calibrated digital voltmeter (DVM) is necessary to verify and adjust the analog outputs of the Model 211 at installations where this interface is used for data transfer. Refer to the manufacturer's manual for specific operating instructions for this instrument. Various makes and models may be used at Florida ambient air monitoring stations.

   Note: Ensure that the calibration of this audit device is current before use.

8.0. Installation, Start-Up and Removal Instructions

8.1. Unpacking

The Model 211 ozone monitor (see Diagram 14.6, *2B Tech. Model 211 O_3 Monitor Front Panel;* Diagram 14.7, *2B Tech. Model 211 O_3 Monitor Rear Panel*) is shipped complete in one container. If, upon receipt of the ozone monitor, there is obvious damage to the shipping container, notify the carrier immediately and hold for inspection, as this would be the carrier's responsibility.

Open the shipping box and verify that it contains the following:

1. Model 211 Scrubberless Ozone Monitor
2. AC Power Adapter (100-240 VAC to 12 VDC) with Country-Specific Plug
3. Zeroing Cartridge
4. Portable N2O Source (use with either 16-gram or 8-gram N2O cartridges, for 8 hr or 4 hr of continuous operation)
5. SD Card (minimum 2 GB) and SD Card Reader

6. Operation Manual on USB Stick
7. Calibration Data and NIST-Traceable Calibration Certificate
8. Instrument Birth Certificate

Save all packing material until all contents have been identified and assessed. If anything is missing or obviously damaged, contact 2B Technologies immediately.

8.2. Installation Procedures

The physical configuration of ozone monitoring instruments at Florida air quality monitoring stations is shown in Diagram 14.9, *Station Layout*, and Diagram 14.8, *Single Line Input Arm Diagram*.

Inlet tubing may be attached to the ¼ inch nylon Swagelok fitting on the back of the instrument. The inlet tubing should be made of PTFE Teflon®, FEP Teflon®, PFA or some other inert material that does not destroy ozone and that does not desorb plasticizers and other organics that can contaminate the flow path. The length of tubing should be kept as short as possible (not more than a few feet) to minimize ozone destruction. Tygon®, polypropylene (which may look like Teflon®) and metal tubing should not be used. Teflon-lined Tygon® tubing, which is used inside the instrument, provides the flexibility of Tygon® with the inertness of Teflon®.

Use ¼" OD x ⅛" ID tubing for the sample line for Model 211 installations. The smaller bore of the "thick wall" tubing reduces gas residence time within the sample intake system at the normal operating flow rates of a standard Model 211. Tubing connected to the ozone primary standard, including the SLIC line, should use wide bore, "thin wall" tubing of nominal 3⁄16" ID to pass the c. 1.5 l/min flow rate of zero air or calibrator without backpressure problems.

The manufacturer recommends an external Teflon® inlet filter to prevent internal contamination of the tubing and absorption cell by particulate matter. For this application, use a 47 –mm diameter, 5-um PFTE filter (See Section 9.11, *Inspect/Change Sample Line Filter*) in a PFTE filter holder designed for gas filtering applications with compatible fittings. This filter is placed as close as possible to the inlet on the back panel of the Model 211. The filter should be periodically tested for ozone loss and clogging by fine particulates (See Section 9.11, *Inspect/Change Sample Line Filter*).

Note: Never operate the Model 211 without an external sample line filter installed. All instrument operations, including calibrations, should be done through an external filter unless this SOP notes otherwise.

At Florida air monitoring stations, the Model 211 is interfaced with a Model 8872 Data Acquisition System (DAS) using the built-in 9-pin serial port. The Model 8872 DAS is configured to interpret the serial data stream from the Model 211, integrate ambient ozone averages, combine these data with other station observations, and store everything for later transmission. Plug the one end of the manufacturer-supplied 9-pin, "straight-through", female-female serial cable into the Model 211 and the other end into a free serial port on the 8872 DAS. The serial port on the 8872 DAS is configured as described in the latest Florida PQAO SOP for this instrument. The Model 211 communications configuration is described in Section 10.7, *Collecting Data over the Serial Port in Real Time*, of this SOP document.

It is also possible to interface auxiliary equipment to the Model 8872 DAS via analog connections. Analog data connections are principally used for convenience, or to support the collection of site ancillary data: Data from every channel are integrated simultaneously and may be inspected remotely. Before using the analog inputs of the Model 8872 DAS for recorded data, be sure they are verified as described in the latest Florida PQAO SOP for the Model 8872 DAS.

The Model 211 requires a 12 V DC source which can be supplied by: 1) the 110-220 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 11-14 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. 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.

8.3. Start-up Procedures

To operate the Model 211 ozone monitor, connect it to an external power source and turn the instrument on by flipping the front panel switch. Once turned on, the instrument will display the version number of the software installed on the microprocessor followed by a display of the time and date. After a few seconds, the instrument will start displaying readings for ozone and the temperature and pressure of the absorption cell. 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. Successive ozone readings may also be inaccurate during the 20 minutes required for the lamp, photodiode, and internal temperature of the absorption cell to stabilize.

The N2O pressured inlet must be connected to the 211, where labeled on back panel before allowing flow to the instrument. A two-stage gas regulator with a shut off valve will provide the needed flow to the instrument. A PSI setting around 10psi is adequate. An exhaust line must be vented outside of monitoring station for safety concerns.

Before beginning any ambient monitoring, it is necessary to perform an adjusted calibration as described in Section 10.8, *Calibration Procedures*.

The instrument covers should remain in place while the instrument is collecting ambient data to prevent vibration, dust or electrical noise from affecting instrument operation.

8.4. Removal Procedures

If the instrument is collecting data, it is important to terminate data capture gracefully and document that the ozone monitor was shut down. If the ozone monitor is to be turned off for any reason listed below, then a zero, span and precision check must be performed before that shutdown:

1. Removal from service longer than 4 hours
2. Major maintenance is planned or anticipated
3. Replacement of the associated ozone monitor
4. For any other reason which the operator feels may require readjustment of either the zero or span calibration coefficients, upon turning the power back on

If the shutdown was unplanned, then run an automated or manual (depending upon the nature of the disruption) zero, span and precision check within 24 hours of restoring the instrument to operation. Other quality assurance checks may also be required depending on the circumstances of the shutdown.

No special procedure is required to shut down the ozone monitor. Simply turn off the power to the instrument on the front panel. Removing the AC line cord and electrical I/O lines prior to opening the instrument cabinet for interior work is a prudent safety precaution. The manufacturer recommends a grounded anti-static wrist strap be employed during any work inside the cabinet.

If moving or storing the instrument, cover the ports on the back of the instrument to prevent dirt or moisture entering the instrument. Duct tape will work in the absence of a NPT plug.

9.0. Instrument Calibration

Upon completion of installation, start-up and calibration procedures, the ozone monitor is ready to continuously analyze ambient air samples for ozone and will properly respond to calibration gas concentrations supplied by a system such as a Thermo Scientific Model 49i-PS primary standard.

9.1. Maintenance Flag

During normal operation, ambient ozone measurements from either the analog output or the serial output of the Model 211 are continuously recorded by a Model 8872 Data Acquisition System (DAS). Ambient data collection will have to be suspended prior to doing any work on the Model 211, the instrument interconnections, or the instrument calibration. The operator should indicate that data collection is suspended in these circumstances by setting the “Maintenance” flag on the ambient ozone data channel using the front panel controls of the Model 8872 DAS. This will prevent any erroneous data from being recorded and help documents the maintenance period. See the latest Florida PQAO SOP for this instrument for directions how to do this step. Do not forget to remove the “Maintenance” flag on the ambient ozone data channel when any work is complete.

9.2. Determination of Zero Drift

Because of instrument design, obtaining a value to evaluate the zero drift of the instrument in operating configuration requires the following procedure. The procedure is:

A. Retrieve a prior zero level response from an automated Zero, Span and Precision Check.
B. Retrieve a current zero level response reading from a more recent automated Zero, Span and Precision Check. Note the time interval between these checks as there are different zero-drift data quality standards.
C. Compute the difference between these two values. Use this difference as the estimate of zero-drift for the included time interval.

The zero-drift value obtained by the procedure above represents the aggregate zero-drift of the analyzer at the configured averaging time over the measured time interval. It is directly comparable with ozone data quality objectives (Section 11.2, *Control Limits*).

Note: Complete the below test as described. Do not apply any stability criterion.

A more sophisticated zero-drift assessment may be performed during a manual Zero, Span and Precision Check (See Section 9.9, *Zero, Span and Precision Check*). The procedure is:

A. Supply the Model 211 with a high-quality source of zero air and allow the instrument readings to stabilize. Verify that the internal temperatures have stabilized. Zero air should be delivered through the normal sampling inlet system.
B. Collect a series of 10 consecutive data points from the front-panel display of the Model 211 at the normal averaging rate while under the calibrated condition.
C. Verify the quality of the data by computing the sample standard deviation is less than or equal to 1.0 ppbv. Values larger than this indicate a problem that requires attention.

D. Compute the mean response for the Model 211. Use this value as the estimate of the current zero drift.

Note: The zero-drift value obtained by the procedure above represents the current response of the analyzer at the specific averaging time to zero air. It is not directly comparable with data quality objectives as it will need to be compared with another value obtained by the same procedure at an earlier time. However, this procedure may indicate problems that may be hidden by averaging on the Model 8872 DAS and is useful as a diagnostic tool.

Note: The instrument "zero" described by the procedure above is not the same as the "electronic zero" referred to by the *Lamp Test* procedure on Page 19 of the *Ozone Monitor Model 211 Operation Manual* (See Section 12.0, *References*). The *Lamp Test* procedure refers only to parameters of lamp sub-system performance.

9.3. Front Panel Operation

The Model 211 menu is accessed using the rotary encoder control on the front panel of the instrument labeled "Select". This control may be rotated in either direction as well as depressed or "clicked" (like a computer mouse button) to operate functions. To reach the menu, depress the "Select" control until the display shows:

Menu

Then, release the control. The display will now show:

Menu

Dat Avg Cfg Svc ←

A blinking cursor will show across the **D** of the **Dat** submenu indicating that it is selected. The submenus **Dat**, **Avg**, **Cfg** and **Svc** may be selected by rotating the "Select" control clockwise or counterclockwise to move the cursor under the first letter of one of the other submenus or the "arrow" character. To select a particular submenu, move the cursor under the first letter of a submenu and depress the "Select" control. To exit the menu system and resume measurements, rotate the "Select" control until the cursor highlights the right arrow symbol (←) then "click" the "Select" control. The full menu tree for the Model 211 is shown in Diagram 14.4, *Model 211 Menu Tree*.

During normal operation the front panel display will show the measured ozone concentration, cell temperature and cell pressure alternating with the measured ozone concentration, current time and current date. Rotate the "Select" control to the left or the right at least one click and the cell flow rate will appear below the measured ozone concentration.

The Model 211 has two air pumps, a primary pump and a backup pump. The Model 211 normally operates on the primary pump, alone. If the cell flow rate drops below 500 cc/min, the instrument will assume the primary pump has failed. The primary pump will be stopped and the secondary pump will start. In that case, a "^" symbol will appear on the front panel display to indicate to the operator that maintenance is required. Refer to the instrument operation manual for more information on pump status indications and how the dual pump system works (See Section 12.0, *References*).

9.4. Instrument Configuration

The menu system of the Model 211 is used to enter configuration information into the instrument. The Florida standard configuration is tabulated in Diagram 14.5, *2B Technologies Model 211 O_3 Monitor Configuration*. This table is organized in the same manner as the Model 211 menu system.

Note: The FEM approval for the Model 211 requires the averaging time to be set to 1 minute.

Using the navigational functions described in the previous section, navigate to each configuration option in the configuration table and set it to the tabulated value. Calibration settings will be described in Section 10.8, *Calibration Procedures*.

9.5. Functional Checks

Turn the instrument on and let it warm up for at least 10 minutes until internal temperatures have stabilized. Verify the following, using the "Select" control to change displays as necessary:

A. The primary pump is on and no pump warnings ("^" symbols) are showing in the display.
B. The measured ozone reading is a consistent with the source (ambient, zero air, etc.).
C. The cell flow rate is at least 700 cc/min.
D. The cell pressure not more than 20 torr below ambient barometric pressure.
E. The display backlight is "on" if it is so configured.
F. The date and time are correct if logging function is enabled.
G. Gas and electrical connections are secure.

9.6. Collecting Data over the Serial Port in Real Time

Direct collection of data from a Model 211 is more reliable through the standard serial port and this is the preferred interface. To transmit data to a computer over the serial port in real time connect the Ozone Monitor to the serial port of the computer using the manufacturer-supplied 9-pin, "straight-through", female-female serial cable. A "cross-over" cable will not work. Activate your data acquisition software; e.g., Hyper terminal (available on most Windows-based computers) or Tera Term Pro. The later software is preferred since hyper terminal has a 500-line buffer limit, but the user may set the maximum buffer size for Tera Term Pro. However, both programs allow you to log the data to a computer file with no limit on the number of data lines. Using these terminal emulation programs, data may be saved to a text file and then opened in Microsoft Excel (or other spread sheet program) where it may be converted to formatted data in columns by defining delimiters (such as commas and carriage returns) for data manipulation and graphing. The ozone mixing ratio (ppbv), internal cell temperature (K or C), cell pressure (torr or mbar), values of three external analog inputs in volts (if activated from the menu), date, and time are sent as comma-delimited ASCII text to the serial port (2400, 4800 or 19,200 baud; 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 microprocessor menu. Time is provided in 24-hour (military) format, and the date is given in European style (day/month/year).

9.7. Calibration Procedures

This section details the calibration procedure for the Model 211. It is based on the manufacturer's *Technical Note Number 015, Recommended Calibration Procedure for 2B Tech Ozone Monitors* (See Section 12.0, *References*). The Model 211 ozone monitor is required to be calibrated prior to being used for ambient ozone data for the first time. The instrument must also be recalibrated at the following times:

1. Annually.
2. Prior to the resumption of ambient data collection following any major maintenance procedure.
3. If the control limits of an automatic or manual ZSP Check have been exceeded (See Section 9.9, *Zero, Span and Precision Check (ZSP Check)*).

Preset calibration parameters are given in the instrument's "Birth Certificate" and recorded on the calibration sticker viewable with the top cover removed. However, the calibration parameters may be changed by the user. For example, it may be desirable to provide a positive offset by a known amount (e.g., 10 ppbv) if recording data from the single-ended analog output to facilitate tracking zero drift. Because of noise and/or an inherent offset, some measured values will be below zero at very low ozone mixing ratios or while zeroing the instrument with an external scrubber. Also, the instrument zero may drift by a few ppbv over time.

The adjusted calibration consists of challenging the Model 211 ozone monitor with a set of known ozone concentrations generated by the primary standard while documenting response of the Model 211 ozone monitor. Ozone monitor responses to zero air and 4 upscale ozone concentrations (Levels 0 and 1 to 4 in the table below) are used to determine calibration coefficients. Ozone monitor responses at all levels (Levels 1 through 4 in the table below) are used to evaluate the quality of the calibration and the linearity of the of the Model 211 ozone monitor. Gas concentrations used in this procedure are:

TABLE 1. CALIBRATION GAS CONCENTRATIONS

Calibration / Verification Level	Calibration Gas Concentration
0	Zero Air
1	40 ppb
2	70 ppb
3	120 ppb
4	250 ppb

9.7.1. Equipment Required

The following instrument, equipment and supplies are required to calibrate a Model 211 ozone monitor:

1. **Primary Standard and Ozone Calibrator.** Each Model 211 ozone analyzer monitor is paired with a Thermo Scientific Model 49i-PS Primary Standard (TS 49i-PS) or similar. Refer to the latest version of the Florida SOP for operating instructions and procedures. The primary standard requires annual calibration and recertification. Ensure that the certification is current before using to calibrate the Model 211 ozone monitor.

2. **Zero Air Supply.** A Zero Air system must be provided which will supply the primary standard with sufficient supply of pollutant-free reference air. Ensure that scheduled maintenance has been performed before use.
3. **Data Acquisition System (DAS).** An Environmental Systems/Agilaire Model 8872 Data Acquisition System (DAS) (Model 8872 DAS, or Logger) is used to create the primary record of the analog outputs of the ozone monitor and primary standard during calibration of the Model 211 ozone monitor. Using the Logger to interpret and display the digital signals representing the ozone monitor response and analog signals representing the primary standard input ensures that both signals are integrated and converted identically. Since the Logger is a principal component at an air monitoring station, there are separate Florida PQAO SOPs for these instruments. Ensure that Logger analog calibrations (if relevant) are current before use.
4. **Teflon® Sample Line and Fittings.** Have available several lengths of clean of ¼" OD "thick wall" (1/8" ID) and "thin wall" (3/16" ID) FEP Teflon® tubing and some Teflon® ¼" Swagelok tubing connectors and a selection of other Teflon® ¼" NPT and tubing hardware to interconnect instruments and form exhaust lines or vent caps.
5. **Basic Hand Tools.** This list should be supplemented with some specialty items: Sample line filter handling forceps, Manufacturer's wrench set for opening the sample line filter housing.
6. **Consumables and Spare Parts.** As needed.
7. **Forms.** The spreadsheet form shown in Form *DEP 06-XX-C Calibration* to compute the calibration constants for the Model 211 and *DEP 06-XX-C Multipoint* to as a reference for the instrument's linearity performance.

9.7.2. <u>System Configuration for Calibration</u>

The calibration instructions will assume that the instruments are deployed at an active air monitoring site in the standard configuration described by this SOP. The arrangement of the instruments and operating equipment within the shelter of an air monitoring site is shown in the diagram in Diagram 14.9, *Station Layout*.

Note: If the Model 211 Ozone Monitor is not already operating, turn it on and allow it to stabilize for a minimum of one hour before attempting to calibrate.

The flow volume from the primary standard in working configuration is sufficient to reach an atmospheric pressure mixing point at the end of the single line inlet arm shown in the diagram of Diagram 14.8, *Single Line Input Arm Diagram*. When directly connected to the back of the Model 211 during a SLIC a vent is required to prevent over-pressurizing the ozone monitor. A simple tee-connector at the end of the SLIC line where it connects to the back of the Model 211. The open side to the tee connector may be connected using an extra piece of ¼" tubing to the exhaust side of the shelter exhaust manifold to prevent calibration gases from accumulating inside the air monitoring station shelter.

9.7.3. <u>Preparation for Calibration</u>

Prior to beginning calibration of the Model 211 ozone monitor, a companion primary standard will be in an idle mode where the pump is off. The instrument pump will have to be turned on. The Logger will control this feature. The TS 49i-PS works best when allowed to warm-up for at least 2-hours on zero air before use. Other primary standards may have similar requirements – refer to the Florida PQAO SOP. Data collection may continue while the primary standard is warming-up but must be suspended during calibration procedures. See the procedure in Section 10.1, *Maintenance Flag*.

9.7.4. Calibration Procedure

The calibration procedure for the Model 211 is:

Note: Any automatic nightly Zero, Span and Precision check program control must be disabled during calibration.

Note: For Florida air quality programs, the practical definition of "stability" is defined as 10, 1-minute integrated average ozone readings within 3 ppb on the data collection device. However, more time may be allowed during calibrations to achieve closer agreement.

Instrument Preparation

A. Verify that the primary standard and zero air system are on, warmed up, and ready for use. During calibration, it is convenient to adjust the front panel display or reporting output of the Model 8872 DAS to produce a scrolling report of Ozone monitor and Primary standard channels at the base averaging interval. Refer to the latest version of Florida PQAO SOP document for the procedure.
B. Enter the calibration menu on the Model 211 (**Main Menu\Cfg\Cal\O$_3$**), and after recording the "as found" zero (**Z**) and slope (**S**) parameters on the on the form shown in *Form DEP 06-XX-C Calibration,* set the zero (**Z**) value to 0 and the slope (**S**) value to 1.00.
C. Connect the ozone monitor to the output manifold of the ozone calibrator. If a sample line particle filter will be used in normal operation, the calibration must be performed through the filter. The manifold must be vented to atmosphere so that pressure does not build up in the calibration setup.

   Note: Connection of the Model 211 directly to a pressurized output of any device can damage the ozone monitor.

D. Verify that the flow rate into the manifold is greater than the total flow required by the ozone monitor plus any other flow demand drawing from the manifold such as a UV photometer or ozone transfer standard.

Measurement of Zero Air

E. Verify that the zero-air supply configuration. The same zero air supply used to supply the calibrator's ozone generator must be used for the calibration procedure.
F. Allow the Model 211 to sample zero air until the response is stable.
G. Record 10 successive, 1-minute average observations of the Model 211 zero air response and the primary standard zero air response from the front panel display of the Model 8832 DAS (or the equivalent report from the 8872 DAS) in the spaces provided on Form *DEP 06-XX-C Adjusted Calibration*.

Note: When provided input data as described in this procedure, the spreadsheet version of the form shown in *Form DEP 06-XX-C Calibration* will perform a few basic functionality calculations on the Model 211 as described by the manufacturer in manufacturer's

***Technical Note Number 015, Recommended Calibration Procedure for 2B Tech Ozone Monitors* (See Section 12.0, *References*).**

Measurement of Upscale Ozone Standards

H. Generate a span-level ozone concentration (Level 4 from the table in Section 10.8, *Calibration*) with the primary standard and allow the ozone generator to warm up for at least 5 minutes. The same zero air supply used for making zero air measurements must be used for the upscale ozone concentrations.
I. Allow the Model 211 Ozone Monitor to sample the ozone concentration supplied until a stable response is measured.
J. Record 10 successive, 1-minute average observations by the Model 211 and the primary standard from the front panel display of the Model 8832 DAS real-time continuous report (or the equivalent report from the Model 8872 DAS) in the spaces provided on the form shown in Form *DEP 06-XX-C Calibration.* The response at this value and the response to zero air, are used to compute the calibration factors for the Model 211.
K. Generate the other intermediate ozone concentrations from the table in the Section 10.8, *Calibration*. A total of at least 4 upscale ozone concentration standards are recommended over the range of interest.
L. For each ozone concentration standard, record 10 successive, 1-minute average observations by the Logger in the spaces provided on the form shown in Form *DEP 06-XX-C Calibration*. The responses at the intermediate ozone concentrations are used to verify the linearity of the Model 211. They are not used in the calibration constant calculations.

Determine Calibration Curve

M. Plot the Model 211 responses (x-axis) versus the corresponding standard ozone concentrations (y-axis). The spreadsheet version of the adjusted calibration form will do this automatically (Section 12.9, *Adjusted Calibration*).
N. Fit the data to a straight line (e.g. $y = mx + b$) using linear regression techniques to determine the relationship between test gas concentration and ozone monitor response. Plot the fitted regression line. The spreadsheet version of the adjusted calibration form will do this automatically (Form *DEP 06-XX-C Calibration*).
O. Examine both the calibration plot and fitted regression line. Determine if any points deviate significantly from the line, which is an indication of an error in determining the calibration relationship. The Model 211 should be linear over the range of ozone values used in this calibration procedure. The most likely sources of any errors in the Model 211 are leaks, a malfunctioning ozone scrubber, a contaminated valve, or contamination in the optical setup. See the "Troubleshooting" section of the Model 211 operating manual**.**

The slope of the line is the gain factor (S) and the intercept is the offset (Z) that need to be applied to the ozone monitor response to calibrate it to the primary ozone standard.

Note that the sign of the offset (Z) needs to be changed to be in the form expected by the Model 211 operating software. The spreadsheet version of the adjusted calibration form will do this automatically (*Form DEP 06-XX-C Calibration*).

Note that the calibration of the (Z) should expect to be close to actual zero.

On the front panel of the Model 211 ozone monitor, depress the "Select" control until the display shows:

Menu.

Then, release the control. The display will now show:

Menu

Dat Avg Cfg Svc ←

To change the calibration parameters, select **Cfg** from the **Main Menu**:

Cfg Menu D/T Cal I/O Unt ←

Now use the rotary select switch to select and click on **Cal**.

Cal Menu Fm O_3←

By selecting **O_3**, the following submenu with the values of the current calibration parameters will then appear:

O_3 Cal Menu

Z=-2 S=1.01

Select desired parameter to calibrate, and then use the "Select" control to adjust the value, turning it to the left or right. Once completed, return instrument to idle state and begin performing a multipoint (See Linearity check)

Concordance Test

Using any test gas concentration, including trending concentrations, verify concordance of the communication between the Model 211 Monitor, the primary standard and the Logger:

Note: The following procedure assumes the interfacing described in Sections 8.0 I*nstallation, Start-up and Removal* and 9.0 *Instrument Calibration* where this test compares a digital representation test gas concentration (from the Model 211, via the serial interface) to an analog representation (from the primary standard, via the analog interface). Other interface options are possible.

A. Change the report format of the Model 8872 DAS to show a real-time ("Un-averaged"), continuous report of Ozone (O_3) and Primary Standard (PS1) channels. Refer to the latest version of the Florida SOP for the Logger model used for this procedure.

B. The normal operating mode of front panel display of the Model 211 and the primary standard should continuously update current observations at the specified standard updating intervals; refer to the relevant Florida SOP for adjustment instructions if it is set to a different display.

C. Note in the "Concordance Checks" section of the adjusted calibration form (Form *DEP 06-XX-C Calibration*) four successive pairwise ozone observations from the front panel of the Model 211 and the DAS "O_3" channel followed by four successive, pairwise observations of the DAS "PS1" channel and the front panel of the primary standard. In both cases, the pairwise ozone values should be similar, but need not be equal.

D. Note the time of day clock setting on the DAS and the time of day clock on the cellular phone network and record these on the adjusted calibration form in the space provided. These should be similar but need not be equal.
E. Restore the normal front panel display of the Model 8872 DAS.

Linearity Check

Perform the following post-calibration procedures, referring to the section of this SOP cited for detailed procedure:

A. Perform a manual Multi-Point Check of the calibrated instrument (Section 9.13, *Multi-Point Check*) using the ozone test levels specified in the Multi-Point Check procedure.
B. Verify instrument linearity over the range used for the Multi-Point Check. This is a sensitive test of overall instrument performance. Refer to Section 11.2, *Control Limits,* for linearity calculations and linearity control limits.
C. Perform a SLIC (Section 9.9, *Sample Line Integrity Check (SLIC)*).
D. Restore the original gas connections to all instruments used in this procedure.
E. Generate zero-air and purge the entire sample inlet line system, sample line filter, and all instruments used in the process.
F. Completion of the calibration procedure during scheduled preventative maintenance is documented on the form in Form *DEP 06-XX-A Preventative Maintenance.*

Ambient data collection may be resumed at this point. Remove the Maintenance flag on the DAS Ozone channel.

Note: Restore automatic nightly Zero, Span and Precision check program control.

9.8. Zero, Span and Precision Check (ZSP Check)

To achieve data of the highest confidence, quality assurance guidelines require the ozone monitor to respond within specified limits when challenged with three concentrations of ozone on a bi-weekly (once every 14-day period) basis. The manual process has largely been superseded by automation with a system that performs this quality check every night and stores the results in the Logger database. The manual procedure described in this SOP may be desirable under certain circumstances (e.g. repairs, calibrations).

The manual Zero, Span and Precision Check (ZSP Check) consists of challenging the Model 211 with a set of known ozone concentrations generated by the primary standard while documenting the response of the Model 211. Ozone monitor responses at the zero and span levels (see the table below) are used to verify that the instrument calibration is correct. The instrument response at the precision level is used to evaluate precision of the Model 211. Gas concentrations used in this procedure are:

Note: Accuracy is evaluated during the internal performance evaluation.

TABLE 2. MANUAL ZERO, SPAN AND PRECISION CHECK GAS CONCENTRATIONS

Calibration / Verification Level	Calibration / Verification Concentration Range	Calibration / Verification Gas Concentration
Zero	0 ppb	Zero Air
Precision	10 ppb -- 80 ppb	70 ppb
Span	The alternative level in Section 4.1, *Definitions*	250 ppb

In addition to the above requirements, it is necessary to evaluate the amount of Zero Drift and Span Error of the ozone monitor. Use the procedure of Section 9.2, *Determination of Zero Drift* to obtain suitable zero bias values for the Model 211. Span Error may be evaluated using the results obtained in this procedure.

9.8.1. ZSP Check Preparation

Data collection may continue while the Model 49i primary standard is warming up. Data collection must be suspended during steps that will disturb the output of the Model 211. See the procedure in Section 9.1, *Maintenance Flag*.

Note: The automatic nightly Zero, Span and Precision check program control must also be disabled during this operation.

9.8.2. ZSP Check Procedure

This procedure is the combination of two separate, bi-weekly (once every 14-day period) quality assurance checks. The ZSP Check procedure is similar to the Multi-Point Check procedure described in Section 9.13, *Multi-Point Check*. The Model 211 is challenged with a set of known ozone concentrations generated by the primary standard while documenting the response of the Model 211. A ZSP Check uses a zero level plus 2 upscale gas concentrations.

This operation is performed while the instrument is connected to a primary standard through the normal sample line.

Note: For Florida air quality programs, the practical definition of "stability" is defined as 10, 1-minute integrated average ozone readings within 3 ppb on the data collection device.

Perform the ZSP check as follows:

A. Both instruments are connected to the Model 8872 DAS as they normally are, and gas concentration observations are made from the Model 8872 display to ensure that meaningfully paired observations are recorded. The Model 8872 continuous report output is set to a 1-minute integration time for all channels.
B. Generate the Level-Zero (0 ppb) gas concentrations shown in the table in Section 9.9, *Zero, Span and Precision Check (ZSP Check)* (above) using the companion model 49~~e~~i primary standard. Wait until the measurements stabilize, then record 10 consecutive ozone concentration measurements reported by the Model 211 and the corresponding gas concentration from the model 49~~e~~i primary standard.

C. Generate the Level-Span (250 ppb) gas concentrations shown in the table in Section 9.9, *Zero, Span and Precision Check (ZSP Check)* (above) using the companion model 49~~e~~i primary standard. Wait until the measurements stabilize, then record 10 consecutive ozone concentration measurements reported by the Model 211 and the corresponding gas concentration from the model 49~~e~~i primary standard.
D. Generate the Level-Precision (70 ppb) gas concentrations shown in the table in Section 9.9, *Zero, Span and Precision Check (ZSP Check)* (above) using the companion model 49~~e~~i primary standard. Wait until the measurements stabilize, then record 5 consecutive ozone concentration measurements reported by the Model 211 and the corresponding gas concentration from the model 49i primary standard.
E. Generate Level-Zero gas concentration and purge the entire sample inlet line system, sample line filter, and all instruments used in the process.

Compare the average gas concentrations reported by the Model 211 ozone monitor with those generated by the primary standard and with the control limits on the record form.

The results of this check are recorded on the Multi-Point check Form *DEP 06-XX-B Multi-Point Check*. Ignore form columns for unused test gas concentrations.

9.9. Sample Line Integrity Check (SLIC)

The sample lines must be clear of obstructions and free of material which may absorb or react with ozone. The long, single line inlet structure now used at Florida air monitoring sites may be particularly sensitive to these problems. The entire inlet line is completely replaced annually (See Form *DEP 06-XX-A Preventative Maintenance*). A SLIC verifies inlet system performance in the interim. This operation is performed while the instrument is connected to a primary standard either through the sample line or directly through the SLIC line.

The minimum frequency for SLICs is “quarterly” as shown on Form *DEP 06-XX-A Preventative Maintenance*.

Make a SLIC line using a short length of ¼” OD x 3/16” ID “thin wall” FEP or PTFE tubing long enough to reach from the ozone outlet of the Model 49i primary standard to the sample inlet of the Model 211. When directly connected to the back of the Model 211 during a SLIC, a vent is required to prevent over-pressurizing the Model 211. A simple tee-connector at the end of the SLIC line where it connects to the back of the Model 211 is a sufficient vent. The open side to the tee connector may be connected using an extra piece of ¼” “thin wall” tubing to the exhaust side of the laminar flow manifold or a carbon cartridge to prevent calibration gases from accumulating inside the air monitoring station shelter.

Note: Once assembled, reserve the SLIC line assembly for future SLIC checks. Replace this assembly annually.

Note: For Florida air quality programs, the practical definition of “stability” is defined as 10, 1-minute integrated average ozone readings within 3 ppb on the data collection device.

The SLIC procedure is:

A. Connect the ozone outlet on the companion primary standard to the calibration gas line on the single line input system (*See* Diagram 14.9, *Station Layout*).

B. Generate a span-level ozone gas concentration (c. 250 ppb) using the companion model primary standard and send this through the full sample line system including the sample line filter into the Model 211.
C. Record the measured ozone gas concentration reported by the Model 211 once it stabilizes.
D. Connect the ozone outlet of the companion primary standard directly (bypassing the sample line inlet filter housing) to the sample inlet of the Model 211 using the SLIC line assembly. Do not forget the SLIC line vent.
E. Record the measured ozone gas concentration reported by the Model 211 through the SLIC line once it stabilizes.
F. Remove the SLIC line and restore the original connections to all instruments.

Calculate the percentage difference between the ozone concentration observed through the SLIC line versus the ozone concentration observed through the sample line and sample line filter. The percentage difference should be less than 2%.

Document this operation on the Form *DEP 06-XX-B Multi-Point Check*. There are spaces to record all SLIC data plus the calculated percentage difference.

Note: A SLIC can ONLY be documented on Form DEP 06-XX-B *Multi-Point Check.* A manual ZSP Check or manual Multi-Point Check procedure must be used when a SLIC is performed.

9.10. Inspect/Change Sample Line Filter

The sample line filter contains a 47 mm diameter PTFE Teflon filter element with a 5-um pore size (Millipore Mitex Type LS). This filter should be replaced periodically (See Form *DEP 06-XX-A Preventative Maintenance*). An optical bench pressure more than 20 torr below ambient barometric pressure or a 20% drop in bench flow through the Model 211 from the value observed after the last filter change is an indication that the sample line filter may be obstructed.

Note: This process is done while the instruments are on, but it should be done quickly to limit the amount of unfiltered air from being drawn into the gas flow pathway of the Model 211.

Change the filter element as follows:

A. Open the filter housing by separating one half from the other. The manufacturer provides a set of wrenches for this purpose.
B. Inspect the position and condition of the old filter element before removing or disturbing the filter element.
C. Filter replacement is not necessary if the filter element appears clean and functional and replacement is not otherwise required by the preventative maintenance schedule. If these conditions are true, this procedure is complete.
D. Replace dirty filter elements. Using filter forceps, remove and install the new filter element, and then close the assembly by re-joining the two filter housing halves.
E. New sample line filters may destroy ozone. If a new filter was installed, generate a span-level ozone gas concentration (c. 250 ppb or greater) using the companion primary standard and send this through the full sample line into the Model 211. The actual value is not critical, but it should be relatively high concentration. Pacify the sample line filter at this gas concentration for several minutes (c. 10 minutes).

F. Perform a SLIC after a filter change (Section 10.10, *Sample Line Integrity Check (SLIC)*).

Document the results of this operation on Form *DEP 06-XX-B Multi-Point Check*.

Note: A SLIC can ONLY be documented on Form *DEP 06-XX-B Multi-Point Check.* A manual ZSP Check or manual Multi-Point Check procedure must be used when a SLIC is performed.

9.11. Preventative Maintenance Check

Check the preventative maintenance schedule for the Model 211 and do any required preventative maintenance. Each instrument will have its own preventative maintenance record. Preventative maintenance is scheduled on a regular calendar basis. The preventative maintenance record and schedule is found on the Form *DEP 06-XX-A Preventative Maintenance*. Consult the preventative maintenance schedule for the instrument and determine what preventative maintenance checks are due. If no maintenance is scheduled, ambient data collection may be resumed at this point.

Maintenance procedures are described in Section 10.0, *Instrument Maintenance*. Before beginning any maintenance procedure, familiarize yourself with the general layout of the components inside the Model 211 ozone monitor by reviewing 14.1, *Model 211 Interior Top View;* 14.2, *Model 211 Interior Bottom View*; and 14.3, *Model 211 PC Board Detail*. Also, see Figure 1 on Page 2 of the *Ozone Monitor Model 211 Operation Manual*.

Review each scheduled preventative maintenance procedure in this SOP document. Follow all procedural cross-references to develop an understanding of every step or sub-procedure and how they relate to each other. Before beginning, assemble the tools, instruments and supplies needed for the required tasks and clear a suitable-sized work area.

Portable instruments like the Model 211 to be removed for maintenance in the instrument shop. Cover all open gas fittings on the instrument and at the site after removing the instrument. Leave the sample line filter assembly attached to the back panel of the instrument. Return the instrument to the site before doing any operation requiring a calibrated ozone source.

9.12. Multi-Point Check

The procedure described in this section is an optional manual procedure provided so the operator has a means of evaluating the calibration and operation of the Model 211 over the same range of gas concentrations used in a Multi-Point calibration.

This procedure is indicated when the operator suspects there is a problem with the Model 211 and needs a more sensitive test of the instrument performance.

9.12.1. Verification versus Calibration

The Multi-Point Check is a verification procedure. The role of verification versus calibration in the ambient ozone measurement system is described in the following excerpt:

> *Since the term calibration is associated with an adjustment in either the instrument or software, these adjustments should be minimized as much as possible. Sometimes performing frequent adjustments to provide the "most accurate data possible" can be*

self-defeating and be the cause of additional measurement uncertainty. For example, adjusting an instrument based upon a standard that might be degrading or contaminated may actually cause data to be farther from the true concentration. Therefore, quality control procedures that include measurements (e.g. 1-point QC, flow rate verifications, etc.) and Multi-Point calibration verifications are considered "checks without correction" and are used to ensure the instruments are within the calibration tolerances. Usually these tolerances have been developed so that as long as the instrument is within these tolerances, adjustments do not need to be made. However, verifications should be implemented at reasonable frequencies to avoid invalidating significant amounts of data.

Source: QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, EPA-454/B-13-003, May 2013, Section 12.0.

9.12.2. <u>Multi-Point Check Procedure</u>

The manual Multi-Point Check procedure is similar to the manual ZSP Check procedure described in Section 9.9, *Zero, Span and Precision Check (ZSP Check*). The Model 211 is challenged with a set of known ozone concentrations generated by the primary standard while documenting the response of the Model 211. A Multi-Point Check uses a zero level plus 4 upscale gas concentrations, two more than used in a ZSP check:

TABLE 3. MANUAL MULTI-POINT CHECK GAS CONCENTRATIONS

Calibration / Verification Level	Calibration / Verification Concentration Range	Calibration / Verification Gas Concentration
0	0 ppb	Zero Air
1	-	45 ppb
2 (Precision point)	5 ppb - 80 ppb	70 ppb
3 (Mid-point)	-	120 ppb
4 (Span point)	c. 80% Calibration Scale (0 ppb – 300 ppb)	250 ppb

Note: For Florida air quality programs, the practical definition of "stability" is defined as 10, 1-minute integrated average ozone readings within 3 ppb on the data collection device.

To perform a Multi-Point check, follow the procedure for a ZSP check described in Section .9, *Zero, Span and Precision Check (ZSP Check*) with the following changes:

A. After completing the assessment of the span-level gas concentration, assess the Model 211 performance at Calibration/Verification level 3 from the above table.
B. After completing the assessment of the precision-level gas concentration, assess the Model 211 performance at Calibration/Verification level 1 from the above table.

There are no other changes. Complete the SLIC and sample line filter inspections, then check to see if any preventative maintenance is scheduled.

The additional data collected by a Multi-Point check allows the verification of instrument linearity. This is a sensitive test of overall instrument performance. Refer to Section 11.2, *Control Limits,* for linearity calculations and linearity control limits.

The results of this check are recorded on the Multi-Point Check Form *DEP 06-XX-B Multi-Point Check.*

10.0. Instrument Maintenance

Ozone Monitor is designed to be nearly maintenance free. Components that require routine maintenance include the NO/NO2scrubber, which should be recharged at least once every two months of operation, the scrubber filter, and the air pump. The pump has a rated lifetime of 15,000 hours (~1 year and 8 months) of operation and will need to be replaced when the flow rates can no longer be brought into range. Operation with a high restriction on the sample inlet will reduce the lifetime of the pump. The instrument is designed so that pump replacement is relatively easy. Other user serviceable components include the lamp, clock battery, and solenoid valves, which are easily replaced should they fail. In addition, the sample inlet filter (user supplied) should be changed as recommended by the filter manufacturer.

Note: The manufacturer recommends a grounded anti-static wrist strap be employed during any work inside the cabinet. This device will not protect the operator from electrical shock.

The functional checks described in Section 9.5; *Functional Checks* should be performed after restoring power to the Model 211. Follow maintenance with a ZSP Check (See Section 9.9, *Zero, Span and Precision Check (ZSP Check)* prior to restoration of ambient data collection. A manually initiated, automatic ZSP Check will be used for this requirement wherever possible.

Note: A manual ZSP Check (See Section 9.9, *Zero, Span and Precision Check (ZSP Check)*) must be used when maintenance includes any sample line components.

10.1. Replace Nitric oxide gas Scrubber

The instrument uses nitric oxide (NO) as a gas-phase scrubber, rather than a solid-phase scrubber. This patented process has the advantage of reducing interferences in the ozone measurement.

The ozone scrubber (Part # SCRBEXT) has an expected lifetime of 18 months of continuous operation. This component is located in the inlet side of the gas flow path (See Diagram 14.1, *Model 211 Interior Top View*). This part is replaced by simply disconnecting the tubing from the fittings at either end of the installed component and replacing it with a new component. Observe flow direction indications. The Nitric Oxide Scrubber is a part that doesn't affect performance of that instrument, using a venting practice to expel gas outside the trailer reduces the concern of contamination within the air monitoring shelter.

The Completion of this maintenance procedure as a preventative maintenance task is documented on Form *DEP 06-XX-A Preventative Maintenance*.

10.2. Check and Replace Air Pump

The Model 211 has a single air pump with the flow rate at approximately 2.0L/min. (See Diagram 14.2, *Model 211 Interior Bottom View*). Normally, the instrument is operating on the primary pump alone. In the event gas flow drops below a manufacturer-set critical level – and the pump is assumed to have failed - (See *Ozone Monitor Model 211 Operation Manual* (Section 12.0, *References*) for a description of the pump status indications). If there were no pump status indications when the instrument was shut done for preventative maintenance, the approximate instrument operating time since the last pump replacement is less than 5000 hours, and the flow through the flow cell is 700 cc/min. or more, then no pump change is needed.

The procedure to replace a pump is:

A. Turn off the instrument and remove power and gas connections. Cover the open ends of any gas connection with tape to prevent contamination entering the gas flow pathway.
B. Remove the instrument top and bottom covers.
C. Identify the pump. See the photo in Diagram 14.2*, Model 211 Interior Bottom View*.
D. Follow the pump wiring through the instrument to its terminal connector on the PC board. Disconnect the connector at the PC board and carefully extract the wire and connector. The connector will be a tight fit through the grommet where it routes to the PC board.
E. Disconnect the gas connections and remove the pump mounting screw; remove the old pump.
F. Install the new pump in the same location as the old pump securing it with the mounting screw and restoring the gas connections.
G. Carefully route the pump electrical connector through the instrument to the previously vacated connector on the PC board.
H. Inspect all gas and electrical connections inside the instrument and make sure they are tight.
I. Replace the instrument covers; restore all external gas and electrical connections.

Completion of this maintenance procedure as a preventative maintenance task is documented on Form *DEP 06-XX-A Preventative Maintenance*.

10.3. Check / Replace Lamp

The spectrophotometer lamp in the Model 211 was selected for long life and should degrade gradually with time. It should be checked at semi-annual intervals as a preventative maintenance task. The lamp should also be checked if the instrument's ozone measurements are excessively noisy or never rise above zero.

The Model 211 has a lamp test function in its operating software. To perform a lamp test from the operating display, depress the "Select" control until the display shows:

Menu

Then, release the control. The display will now show:

Menu

Dat Avg Cfg Svc ←

Use the rotary "Select" control to move the underscore cursor to the **Svc** submenu, click on **Svc**. A submenu will appear, select and click on **Lmp**. When first entering the **Lmp** submenu, the voltage measured by the photodiode detector is displayed. For best performance this voltage should be in the range 0.5-2.15 volts. For detector voltages less than about 0.7 volts, the data may be noisy due to insufficient light intensity to make precise measurements. If the voltage is zero, the lamp is not ignited and may have burned out. For voltages above 2.5 volts, the A/D converter is saturated, and the measured ozone value will always be zero. This could happen if the instrument is very hot so that the lamp output is too bright.

Immediately following display of the detector voltage, the instrument starts measuring an "effective" ozone concentration without switching the solenoid valve on and off. This is an "electronic zero" and should after a few readings settle down to ± a few ppbv. If the value is outside the range -9 to +9, the instrument may not be operating correctly. The display also gives a standard deviation of the electronic zero. For best results, the standard deviation should not be greater than ±2.5. Note that because less averaging is involved, this standard deviation value is not equal to the overall precision of the instrument; it is only diagnostic of lamp fluctuations.

Replacement of the UV Lamp assembly is explained in *Technical Note Number 017, Replacement of UV Lamp Assembly in Model 211 and Model 211 Ozone Monitors*. This procedure can be done by the end-user.

Completion of this maintenance procedure as a preventative maintenance task is documented on Form *DEP 06-XX-A Preventative Maintenance*.

10.4. Solenoid Replacement

The procedure to replace the solenoid is:

A. Turn off the instrument and remove power and gas connections. Cover the open ends of any gas connection with tape to prevent contamination entering the gas flow pathway.
B. Remove the instrument top and bottom covers.
C. Identify the pump needing replacement. See the photo in 14.1, *Model 211 Interior Top View*.
D. Follow the pump wiring through the instrument to its terminal connector on the PC board. Disconnect the connector at the PC board and carefully extract the wire and connector. The connector will be a tight fit through the grommet where it routes to the PC board.
E. Disconnect the gas connections and remove solenoid mounting screw; remove the old solenoid.
F. Install the new solenoid in the same location as the old, securing it with the mounting screw and restoring the gas connections.
G. Carefully route the solenoid electrical connector through the instrument to the previously vacated connector on the PC board.
H. Inspect all gas and electrical connections inside the instrument and make sure they are tight.
I. Replace the instrument covers; restore all external gas and electrical connections.

As a part that doesn't have a life expectancy the instrument will begin to produce erroneous data and be evident that the solenoid has failed.

10.5. Clean Instrument

The procedure for basic cleaning of the Model 211 is:

A. Turn off the instrument and remove power and gas connections. Cover the open ends of any gas connection with tape to prevent contamination entering the gas flow pathway.
B. Wipe the exterior of the instrument cabinet with a clean, soft, lint-free cloth.
C. Wipe the LCD display and controls with LCD screen cleaning wipe of the type used for laptop computer screens.
D. Inspect the electrical connections on the back of the instrument and make sure that all are clean and bright. Use contact cleaning solution, if needed.
E. Inspect the gas connector on the back of the instrument and make sure it is in good condition.
F. Remove the instrument top and bottom covers and carefully blow out the interior with shop air.

G. Inspect all gas and electrical connections inside the instrument and make sure they are tight.
H. Replace the instrument covers; restore all external gas and electrical connections.

The manufacturer has provided an internal cleaning procedure that cleans the gas pathway. This is not an SOP preventative maintenance procedure and is to be used only if contamination of the gas flow pathway is suspected. See *Technical Note Number 018, Cleaning Procedure for Model 211 Ozone Monitor* for the procedure. This procedure can be done by the end-user of the Model 211, but since it involves chemical solvents it should be done in the instrument shop.

Completion of this maintenance procedure as a preventative maintenance task is documented on Form *DEP 06-XX-A Preventative Maintenance*.

10.6. <u>Temperature / Pressure Verification</u>

The manufacturer does not provide a method to verify the Model 211 internal digital temperature and pressure sensors. The temperature sensor is inaccessible after assembly of the flow cell, and immediate upstream and downstream points in the gas flow pathway pass heat generating components. The pressure sensor is more accessible, but the housing is small and fragile and located in close proximity to other small and fragile components. Nevertheless, the Model 211 has Federal Equivalent Method (FEM) certification without having test points for these sensors.

Given the above considerations, temperature and pressure verification procedure is:

A. Verify that the flow cell temperature reading displayed on the front panel is approximately the current ambient air temperature reported by the audit thermometer. Record the measured and observed values on the record form.
B. Verify the flow cell pressure reading displayed on the front panel is approximately the current ambient air pressure reported by the audit barometer. Record the measured and observed values on the record form.

Completion of this maintenance procedure as a preventative maintenance task is documented on Form *DEP 06-XX-A Preventative Maintenance*.

As experience accumulates with these measurements, tolerances may be established.

10.7. <u>Comparisons and Audits</u>

The performance of the Model 211 may be assessed against a calibrated ozone source in generally the same manner as any other FEM ozone monitor (see the relevant Florida PQAO SOP for the ozone primary standard or the comparison process). Current experiences with these processes and the Model 211 are:

- The gas flow requirements of the Model 211 are half those of “traditional” instruments. It is very important to have an adequate vent where the audit device connects to the end of the sample inlet filter to prevent over-pressurizing the flow cell.
- The Model 211 gas flow system is vented internally inside the instrument cabinet. A protective ozone destruct cartridge located before the air pumps protects the pumps, instrument insides, and operators from ozone present in the calibration gas stream. There is no output that needs to be connected on the back of the instrument.

- The Federal Equivalent Method (FEM) approval for this instrument is to be operated with 1-minute averaging enabled. Legacy monitoring equipment was configured to integrate ozone measurements at one-minute intervals. These were transmitted to the data loggers which averaged incoming data over longer time intervals. The variability of the front panel readings on the Model 211 may seem high.
- The Scrubberless Ozone Monitor uses the proven ultraviolet (UV) absorption method with a patented gas-phase scrubber technology to measure ozone virtually free from interferences. The ozone monitor combines the stability of our proven dual beam ozone monitors with selective scrubber technology to provide accurate ozone measurements in the most polluted. The Logger interface described in this SOP - where both the Model 211 and the primary standard are interfaced to Logger data channels - was specified so that 1-minute averages for each channel are generated within the same averaging interval. This facilitates accurate comparisons between instruments.

10.8. Nitric Oxide Generation Parameters

These parameters can be accessed through the N2O submenu within the Cal menu. Do NOT change these parameters unless you contact 2B Technologies. The slope and the offset values are derived from a factory calibration where the nitric oxide output is compared to the photolysis lamp intensity to calculate nitric oxide in ppb

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11.0. Quality Assurance and Quality Control

Any and all problems causing the loss of 24 hours or more of ambient ozone measurements require formal documentation of the event and the corrective action taken to resolve the problem. Refer to the latest version of Florida PQAO SOP *DEP 01-4 Corrective Action* for instructions and procedures.

Quality assurance issues unique to the operation of the Model 211 are discussed in the following subsections. See the table in the Appendix Section 14.3, *Annual Schedule for QA/QC Tasks* for a consolidated listing of preventative maintenance intervals.

11.1. Calibration of Audit Devices

Audit devices require an annual, NIST-traceable calibration and a calibration certificate from a professional instrument calibration service. The calibration documentation should show both "As Received" and "As Left "data. Inspect both the audit device and the calibration documentation following recalibration and apprise the Quality Assurance Officer of any anomalies (e.g. excessive calibration adjustment, missing parts). Do not use an audit device for any adjustment required by this SOP without a current calibration certificate on file.

In some cases, an audit device has no provision for adjustment or calibration (e.g., thermocouple probe, D/A converter integrated circuit, torque screwdriver). In these cases, only the correct functioning of this equipment can be demonstrated.

11.2. Control Limits

Quality assurance control limits for the Florida ambient ozone measurement system are:

TABLE 4. QUALITY ASSURANCE CONTROL LIMITS FOR OZONE

Parameter	Control Limit	Basis
Zero drift	 ≤± 3.1 ppb ≤± 5.1 ppb	At zero-span checks and zero levels of Multi-Point verifications 24 hr >24 hr-14 day
Span drift	≤± 7.1 % span (250 ppb) concentration	At zero-span checks and zero and span levels of Multi-Point verifications
Linearity	All points within 2% of calibration range (0 ppb – 300 ppb) of best-fit line.	Calculated annually for each ozone monitor during calibration.
Precision	≤± 7.1 % percent difference	At precision checks and precision level of Multi-Point verifications
Sample Line Integrity	< 2% span (250 ppb) concentration	Any SLIC at span concentration during zero-span and precision checks or Multi-Point checks.
Zero Air	Below LDL (< 3 ppb)	During any use of zero air (Model 211 monitor LDL).

Control limits for key parameters are repeated on the forms (Appendices) for the convenience of the operators.

Exceedance of a control limit is cause for implementing formal corrective action procedures. Exceedance of a control limit is not necessarily cause for invalidating data already collected. Complete a zero-span-precision check (if possible) to bracket the data record before taking any corrective actions. Consult with program management for a decision on data usability and integrity.

Computed estimates of the precision and bias of individual instruments are calculated annually from the results of bi-weekly (or more frequent automated checks) single-point quality control checks. These computations use the ozone monitor response to the Precision-level observation in a Zero, Span and Precision check (Section 9.9, *Zero, Span and Precision Check*) - or a Multi-Point check (Section 9.13, *Multi-Point Check*). Estimates of accuracy and bias are based upon independent performance audits conducted by the Air Quality Audit Section of the Division or Air Resources of the Florida Department of Environmental Protection.

The linearity control limit may be determined using a linear regression derived from the instrument calibration coefficients. Calibration curve errors are suggested if the ozone monitor response to the primary standard deviates significantly from a linear relationship. To determine this, compare the actual value reported by the ozone monitor observed at a given primary standard gas concentration to the expected response concentration shown by the regression equation:

Expected Ozone monitor O_3 Conc. =

Zero Coefficient +

[Span Coefficient x True O_3 Conc.]

where:

Zero Coefficient is the ozone monitor background coefficient
Span Coefficient is the ozone monitor 03 coefficient
True O_3 Conc. is the true 03 concentration
Expected Ozone monitor O_3 Conc. is the expected ozone monitor response

Note: The "Zero coefficient" used in the Model 211 Ozone monitor software is actually the inverse of the instrument's measured response to zero air and the sign of this coefficient must be changed before using it in the above equation.

A linearity problem is indicated when the difference between the expected ozone monitor response and the actual response to the primary standard exceeds the control limit shown in the preceding table.

11.3. Warning Limits

The Model 211 is a reliable instrument and the entire ambient ozone measurement system will normally perform well within the control limits tabulated below. Warning limits less stringent than the control limits may be established. These warning limits will represent performance deviations large enough to potentially indicate developing problems with a process or measurement. Program management will ensure that operators are aware of all extant warning limits.

Parameter	Control Limit	Warning Limit
Ozone (O_3)	< ± 7.1%	≥ 5%

11.4. Percent Difference

A quantitative measure of similarity between two values where one is a known or reference value and the other number is the observed or test value. The result is expressed as a signed percentage from the reference value:

% Difference = [Indicated – Actual] / [Actual] x 100

where:

Indicated is the observed or test value
Actual is the known or reference value
% Difference signed difference as a percentage of actual value

All percent difference calculations in this document including the forms in the Appendices are computed using this formula.

NOTE: Some calculations may use integer values versus decimal values

12.0. References

Measurement Principle and Calibration Procedure for the Measurement of Ozone in the Atmosphere. In *National Primary and Secondary Ambient Air Quality Standards*, Title 40 Code of Federal Regulations, Pt. 50, App D, 9-8-14 Ed., GPO, Washington, DC.

Ozone Monitor Model 211 Operation Manual, Revision E, October 2009, 2B Technologies, Boulder CO.

Quality Assurance Project Plan for the State of Florida Ambient Air Quality Monitoring Program, FDEP QAPP-002, Revision 2, March 2017, Florida Department of Environmental Protection, Tallahassee, FL.

Quality Assurance Requirements for SLAMs, SPMs and PSD Air Monitoring. In *Ambient Air Quality Surveillance*, Title 40 Code of Federal Regulations, Pt. 58, App A, 7-1-15 Ed., GPO, Washington, DC.

Technical Note Number 015, Recommended Calibration Procedure for 2B Tech Ozone Monitors, 23 June 2008, 2B Technologies, Boulder CO.

Note: Instruction manual citations in this SOP document are correct for the manual edition listed. The organization of other editions of the instruction manual may vary.

13.0. Appendix A - Forms

13.1. Form DEP 06-20-A Preventive Maintenance

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-A Preventative Maintenance
SOURCE FILE	DEP 06-20-A Preventative Maintenance.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
PAGES	1 of 1

INSTRUMENTS

STATION		PS		LOGGER	
DATE/TIME		SERIAL #		SERIAL #	
ANALYZER		CAL DATE		CAL DATE	
SERIAL #		ZERO		ZERO	
CAL DATE		SLOPE		SLOPE	
ZERO		ZERO AIR	CHARCOAL DATE		SILICA DATE
SLOPE		N2O SERVICE DATE			

MAINTENANCE TASKS

Repairs Completed	Date

Regular Maintenance Tasks			
[ ] Monthly PM	Date	Annual PM (cont'd)	Date
Check Inlet Filter		Ver. Logger Analog IO	
Check N2O output PSI		Verify Met. Sensors	
[ ] Quarterly PM	Date	Ver. Sta. Env. Sensor	
Svc Zero Air Pack		PM/Insp./Cal. Analyzer	
SLIC Check		PM/Inspect Pri. Std.	
		FDEP PS Comparison	
[ ] Semi-Annual PM	Date	Station Ground Test	
Test Analyzer Lamp			
[ ] Annual PM	Date	[ ] As-Needed	Date
Replace Sample Line		Sta. Electrical Svc.	
Replace SLIC Line		Sta. Comm.	
Inspect Logger			

APPROVALS

Operator ______________________ Q/A ______________________

INSTRUCTIONS

Indicate the preventative maintenance interval by checking the "[ ]" box in the label. Record preventative maintenance tasks as they are completed. Note minor repairs or reference corrective actions for major repairs.

Explanation:

Make appropriate entries for the following items:

- Station…refers to monitoring station name
- Date/Time…refers to the current date and time
- Analyzer…insert the make/model of the analyzer (e.g. 2B 211)
- Serial No…refers to the analyzer's serial number
- Cal Date…refers to the date the instrument was calibrated
- Zero...insert the "Zero" calibration factor from the analyzer's operating menu
- Slope…insert the "Slope" calibration factor from the analyzer's operating menu
- PS…insert the make/model of the primary standard (e.g. TS 49i PS)
- Serial No. (2^{nd} Col.)…refers to the primary standard's serial number
- Cal Date (2^{nd} Col.)…refers to the primary standard's last comparison date
- Zero (2^{nd} Col.)...insert the "Zero" calibration factor from the primary standard's operating menu
- Slope (2^{nd} Col.)…insert the "Slope" calibration factor from the primary standard's operating menu
- Zero Air… refers to the zero air conditioning pack and date of service (e.g. silica gel and Charcoal Pack)
- N2O Service Date…refers to the date of the N2O tank
- Logger…insert the make/model of the data logger (e.g. 8872)
- Serial No. (3^{rd} Col.)…refers to the logger's serial number
- Cal Date (3^{rd} Col.)…refers to the date that Logger analog inputs were verified

Additional directions:

- Record maintenance activities in the "Date" fields of the "Regular Maintenance Tasks" section by entering either: (1) today's date if work was performed on the current visit or (2) the previous date these were performed if preventative maintenance is not yet required.
- Date intervals are measured from the calibration date.
- Tick the boxes "[ ]" next to each group of maintenance tasks to indicate which groups were relevant to the current visit. The box next to "Monthly PM" should always be checked. Tick the box next to "Quarterly PM" every third month post calibration and perform these tasks; similarly, perform tasks listed under the "Semi-Annual PM" at the half-year interval and "Annual PM" at the anniversary of the calibration.
- Complete the form, noting any repairs completed in the boxes under the heading "Repairs Completed" with the date of the repair and enter the operator's signature in the "Signature" field at the time work was performed. Route the form for review.

13.2. Form DEP 06-20-B Multi-Point Check

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-B Multi-point Check
SOURCE FILE	DEP 06-20-B Multi-point Check.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
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INSTRUMENTS

STATION		PS		LOGGER		
DATE/TIME		SERIAL #		SERIAL #		
ANALYZER		CAL DATE		CAL		
SERIAL #		ZERO		ZERO		
CAL DATE		SLOPE		SLOPE		
ZERO		ZERO AIR	CHARCOAL DATE		SILICA DATE	
SLOPE		N2O SERVICE DATE				

DISENGAGE AUTO ZSP FUNCTION. TURN ON PS PUMP AND ZERO AIR SUPPLY. GENERATE 0 PPB THROUGH SAMPLE LINE.

DATA

MAINTENANCE PERIOD												
TIME IN MAINT.				TIME OUT MAINT.								
[ ]	ZSP CHECK (0 + SPAN + PRECISION POINT)											
[ ]	MULTIPOINT CHECK (0 + 4 UPSCALE POINTS)											
LEVEL	ZERO		ONE		PREC./TWO		MID/THREE				SPAN/FOUR	
	0 ppb				70 ppb						250 ppb	
			40 ppb		70 ppb		120 ppb				250 ppb	
INSTR.	PS	AN.	PS	AN.	PS	AN.	PS	AN.			PS	AN.
1												
2												
3												
4												
5												
AVG.	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	#DIV/0!
[ ]	SAMPLE LINE INTEGRITY CHECK											
SLIC TIME		TEST CONC. (SPAN)		SAMP. LN. RESP.		SLIC LINE RESP.						
		250	ppb		ppb		ppb					
[ ]	PRIOR **MANUAL** ZSP/MULTIPOINT CHECK AVERAGE ANALYZER ZERO AND SPAN RESPONSE											
DATE/TIME				ZERO AVG.			ppb	SPAN AVG.			ppb	

Multi-Point Check (Cont'd)

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-B Multi-point Check
SOURCE FILE	DEP 06-20-B Multi-point Check.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
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COMPARE CALCULATIONS TO CONTROL LIMITS ON NEXT PAGE. NOTE ANY EXCEEDENCES IN ACTION BOXES.

CALCULATIONS

ZSP/MULTIPOINT CHECK COMPARISON

LEVEL	ANALYZER MEAN RESPONSE TO TEST CONCENTRATIONS											
	ZERO		ONE		PREC./TWO		MID/THREE				SPAN/FOUR	
CONC.		ppb		ppb		ppb		ppb		ppb		ppb
ANA.		ppb		ppb		ppb		ppb		ppb		ppb
DIFF.		ppb		ppb		ppb		ppb		ppb		ppb

LEAST SQUARES FIT OF OBSERVED MULTIPOINT RESPONSE: Y = [SLOPE] * X + [ZERO]

ZERO	#DIV/0!	SLOPE	#DIV/0!

SAMPLE LINE INTEGRITY CHECK

SLIC	ABS. ERROR		ACTION
		ppb	

ZERO AND SPAN DRIFT CHECK (**FROM PRIOR MANUAL ZSP/MULTIPOINT CHECK**)

ZERO	ABS. ERROR		ACTION	SPAN	ABS. ERROR		ACTION
		ppb				ppb	

[ ] LINEARITY CHECK (**MULTIPOINT CHECK, ONLY**)

LINEAR	MAX. ABS. ERROR		ACTION							
		ppb								
	TEST LEVEL	ONE		PREC./TWO		MID/THREE			SPAN/FOUR	
	TEST CONC. (X)	0	ppb	0	ppb	0	ppb	ppb	0	ppb
	LINEAR FIT (Y)	#DIV/0!	ppb	#DIV/0!	ppb	#DIV/0!	ppb	ppb	#DIV/0!	ppb
	OBS. ANA. RESP (Y)	0	ppb	0	ppb	0	ppb	ppb	0	ppb
	DIFF.	#DIV/0!	ppb	#DIV/0!	ppb	#DIV/0!	ppb	ppb	#DIV/0!	ppb

RESTORE AUTO ZSP FUNCTION. MAKE SURE PS PUMP SWITCHES OFF AND ZERO AIR SOLENOID IS CLOSED.
NOTE END OF MAINTENANCE PERIOD AND REMOVE MAINTENANCE FLAG ON OZONE (O3) CHANNEL.

Multi-Point Check (Cont'd)

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-B Multi-point Check
SOURCE FILE	DEP 06-20-B Multi-point Check.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
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CONTROL LIMITS

PARAMETER	CRITERIA	VALUE
SLIC	Error < 2% of Span Level	2% OF Span Level = 5 ppb
ZERO DRIFT	Drift ≤ ± 3.0 ppb (24 hr) ≤ ± 5.0 ppb (24 hr - 14 day)	3.0 to 5.0 ppb (See Left)
SPAN DRIFT	Drift ≤ 7% of Span Level	7% OF Span Level = 17 ppb
LINEARITY (COMPUTED)	All points ≤2% of calibration range of calculated best-fit line	2% of Cal. Range = 6 ppb

OPERATING RANGES

ANALYZER OPERATING RANGE	500	ppb	NORMAL SPAN LEVEL	250	ppb
PRI. STD. OPERATING RANGE	300	ppb	NORMAL PRECISION LEVEL	70	ppb
CALIBRATION RANGE	300	ppb			

APPROVALS

Operator ____________________ Q/A ____________________

INSTRUCTIONS

Indicate using check boxes in DATA block today's checks (ZSP or Multipoint, SLIC, ...). Place ozone (03) and primary standard (PS1) channels on data logger display. Operate PS and record 5 consecutive, 1 m. integrated responses of each data channel from the data logger display. Perform SLIC, Zero/Span drift and Linearity checks if indicated. Complete calculations and return to normal operations if no problems immediately apparent.

Explanation:

Make appropriate entries for the “Instruments” section on Page 1 of the form:

- Station…refers to monitoring station name
- Date/Time…refers to the current date and time
- Analyzer…insert the make/model of the analyzer (e.g. 2B 211)
- Serial No…refers to the analyzer’s serial number
- Cal Date…refers to the date the instrument was calibrated
- Zero...insert the “Zero” calibration factor from the analyzer’s operating menu
- Slope…insert the “Slope” calibration factor from the analyzer’s operating menu
- PS…insert the make/model of the primary standard (e.g. TS 49i PS)
- Serial No. (2nd Col.)…refers to the primary standard’s serial number
- Cal Date (2nd Col.)…refers to the primary standard’s last comparison date
- Zero (2nd Col.)...insert the “Zero” calibration factor from the primary standard’s operating menu
- Slope (2nd Col.)…insert the “Slope” calibration factor from the primary standard’s operating menu
- Zero Air… refers to the zero air conditioning pack and date of service (e.g. silica gel and Charcoal Pack)
- N2O Service Date…refers to the date of the N2O tank
- Logger…insert the make/model of the data logger (e.g. 8872)
- Serial No. (3rd Col.)…refers to the Logger’s serial number
- Cal Date (3rd Col.)…refers to the date that Logger analog inputs were verified

Make the following entries for the “Data” section in Page 1 of the form:

- Time In/Out of Maintenance…refers to the current time that logger ozone channel was placed in or out of “Maintenance” mode
- PS…refers to the primary standard’s indicated concentration (in ppb, whole ppb)
- AN…refers to the analyzer’s indicated concentration (in ppb, whole ppb)

Make the following entries in the “Calculations” section of Page 2 of the form:

- CONC... refers to the primary standard’s mean concentration (in decimal ppb)

- ANA…refers to the analyzer's mean concentration (in decimal ppb)
- DIFF…refers to the error of the comparison (per SOP) (in decimal ppb)
- ABS ERROR or MAX. ABS. ERROR…refers to the absolute value of the error or the maximum absolute value of the error (per SOP) for a comparison (in decimal ppb)
- Action…is used to indicate if any corrective action was begun as a result of a comparison

Additional directions:

- Fields with a green background are required entries used for a ZSP check.
- Fields with a yellow background and a diagonal slash are optional entries used for a Multi-Point check.
- Marking a tick box "[ ]" next to a sub-task indicates that the sub-task was performed and that sub-task entries are complete and evaluated. A SLIC check is one example of a sub-task.
- Retrieve and enter prior manual ZSP/Multi-Point check results (decimal ppb) on Page 2 for drift calculations on Page 3.
- A formal analyzer linearity test can be calculated (Page 3) using the results of a manual Multi-Point check.
- Complete the form with the operator's signature in the "Signature" field on Page 3 at the time work was performed. Route the form for review.

13.3. Form DEP 06-20-C Calibration

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-C Calibration
SOURCE FILE	DEP 06-20-C Calibration.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
PAGES	1 OF 3

INSTRUMENTS

STATION		PS		LOGGER		
DATE/TIME		SERIAL #		SERIAL #		
ANALYZER		CAL DATE		CAL		
SERIAL #		ZERO		ZERO		
CAL DATE		SLOPE		SLOPE		
ZERO		ZERO AIR	CHARCOAL DATE		SILICA DATE	
SLOPE		N2O SERVICE DATE				

PRE-CAL. / POST-CAL. CHECKS

CHECK	RESULT	UNITS
PS - PS **ON**, PUMP **ON**, ZERO AIR **ON**, **SPAN LEVEL** - AS FOUND		
CELL A FLOW		l/m
CELL B FLOW		l/m
CELL A INTENSITY		Hz
CELL B INTENSITY		Hz
BENCH TEMPERATURE		°C
BENCH PRESSURE		mm Hg
ANALYZER AS FOUND		
CALIBRATION DATE		
Z (ZERO) COEFFICIENT		
S (SLOPE) COEFFICIENT		
ANALYZER AS LEFT		
CALIBRATION DATE		
Z (ZERO) COEFFICIENT		
S (SLOPE) COEFFICIENT		
ANALYZER BENCH AS LEFT		
BENCH TEMPERATURE		°C
BENCH PRESSURE		torr

PRE-CAL. / POST-CAL. CHECKS (CONT'D)

CHECK		RESULT		UNITS	
ANALYZER INLET GAS ENV. AS LEFT					
INLET TEMPERATURE				°C	
INLET PRESSURE				torr	
CELL A/B FLOW				cc/min	
N2O FLOW				cc/min	
AUDIT DEVICE					
CAL. DATE					
LOGGER CLOCK CONCORD. W/ CELL NETWORK AS LEFT					
CELL		LOGGER			
LOGGER 03 COMMUNICATION CONCORDNACE AS LEFT					
ANA. O3 CH.	LOGGER	PS PS1 CH.	LOGGER		

Calibration (Cont'd)

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-C Calibration
SOURCE FILE	DEP 06-20-C Calibration.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
PAGES	2 OF 3

DATA

READING	PRIMARY STANDARD CALIBRATION CONCENTRATION LEVELS (ppb)											
	LEVEL 0		LEVEL 1		LEVEL 2		LEVEL 3		LEVEL 4		LEVEL 5	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
AVG.	0	#DIV/0!	40	#DIV/0!	70	#DIV/0!	120	#DIV/0!	250	#DIV/0!		
INSTR.	PS	ANA.	PS	ANA.	PS	ANA.	PS	ANA.	PS	ANA.	PS	ANA.

CALCULATIONS

LEVEL	ANALYZER AVG.	PS CAL. CONC.
0	#DIV/0!	0
1	#DIV/0!	40
2	#DIV/0!	70
3	#DIV/0!	120
4	#DIV/0!	250
5		

CALCULATIONS (CONT'D)

Z OFF.	#DIV/0!	SLOPE	#DIV/0!	Y-INT.	#DIV/0!	
Z COEF.	#DIV/0!	S COEF.	#DIV/0!	Z OFF. D.	#DIV/0!	
UNCAL. MONITOR RESPONSE: Y = [SLOPE] * X + [Y-INT.]						
X-TERM (ppb)		40	70	120	250	
Y-PREDICTED (ppb)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
Y-OBSERVED (ppb)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
DIFF. (ppb)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	

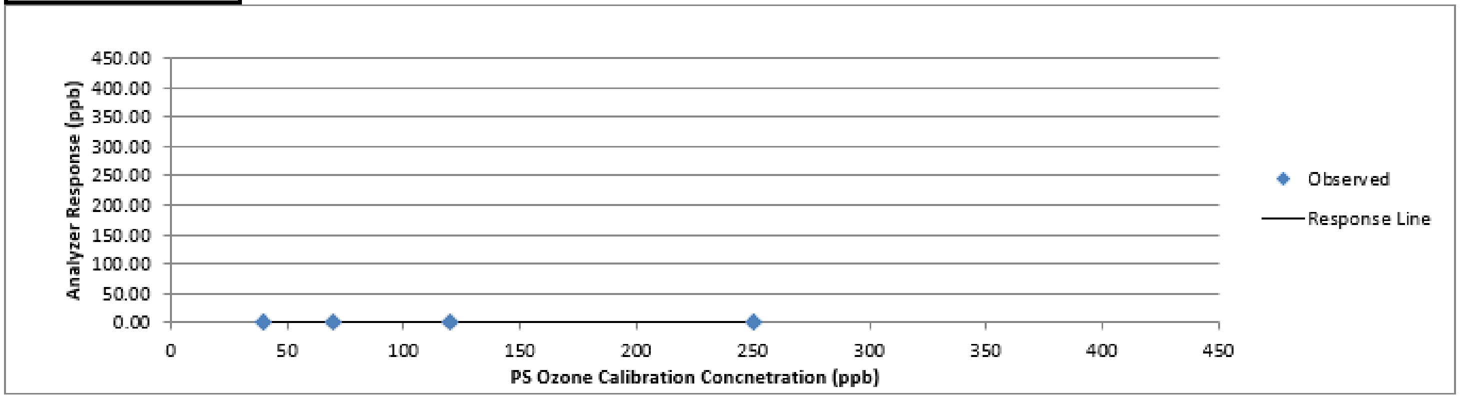
ANALYZER CALIBRATION COEFFICIENTS [Z COEF] AND [S COEF] SHOWN WITH SIGN AND ROUNDING CONVENTIONS REQUIRED BY ANALYZER. DO NOT CHECK LINEARITY - NEW CALIBRATION FACTORS NOT YET APPLIED.

Calibration (Cont'd)

HEADER

AGENCY	FLORIDA PQAO
TITLE	DEP 06-20-C Calibration
SOURCE FILE	DEP 06-20-C Calibration.xlsx
APPROVAL	FLORIDA PQAO
EFFECTIVE DATE	15-Dec-20
PAGES	3 OF 3

GRAPH



CALIBRATION CONTROL LIMITS

PARAMETER	CRITERIA	VALUE
ANALYZER (GUIDELINE)	Measured zero offset ≤2 ppb from calc. zero intercept of regression	2 ppb (See Left)
LINEARITY (COMPUTED)	All points ≤2% of calibration range of calculated best-fit line	2% of Cal. Range = 6 ppb
SLIC	Error < 2% of Span Level	2% of Span Level = 5 ppb

APPROVALS

Operator ____________________ Q/A ____________________

INSTRUCTIONS

Operate PS and record pre-calibration checks. Clear old calibration factors. Apply new calibration factors and complete post-calibration checks.

Explanation:

Make appropriate entries for the "Instruments" section on Page 1 of the form:

- Station…refers to monitoring station name
- Date/Time…refers to the current date and time
- Analyzer…insert the make/model of the analyzer (e.g. 2B 211)
- Serial No…refers to the analyzer's serial number
- PS…insert the make/model of the primary standard (e.g. TS 49i PS)
- Serial No. (2^{nd} Col.)…refers to the primary standard's serial number
- Cal Date (2^{nd} Col.)…refers to the primary standard's last comparison date
- Zero (2^{nd} Col.)...insert the "Zero" calibration factor from the primary standard's operating menu
- Slope (2^{nd} Col.)…insert the "Slope" calibration factor from the primary standard's operating menu
- Zero Air… refers to the zero air conditioning pack and date of service (e.g. silica gel and Charcoal Pack)
- N2O Service Date…refers to the date of the N2O tank
- Logger…insert the make/model of the data logger (e.g. 8872)
- Serial No. (3^{rd} Col.)…refers to the logger's serial number
- Cal Date (3^{rd} Col.)…refers to the date that logger analog inputs were verified

Complete the "Pre Cal./Post Cal. Checks" section on Page 1 of the form. Note that:

- Instrument operating parameters are retrieved though the operating menus for the primary standard (PS) or analyzer.
- Enter "As Found" values for the primary standard (PS).
- Enter "As Found" and, after calibration is complete, "As Left" values for the analyzer.
- Record time and data concordance comparison results in the lower right of Page 1.

Record the data collected by the calibration process in the "Data" section of Page 2 of the form, collected as described in the calibration procedure. Note that:

- A "PS" column label refers to the primary standard's mean concentration (in decimal ppb).
- An "ANA" column label refers to the analyzer's mean concentration (in decimal ppb).
- The remainder of Page 2 will compute the calibration coefficients Z COEF. and S COEF. with the sign and decimal conventions used by the analyzer. A least-squares plot of the input data is computed on Page 3.
- Evaluate the calibration quality by inspection of the input data (Page 2), calculations (Page 2) and graph (Page 3).

- Verify the calibration quality with a manual Multi-Point check of the analyzer using the new computed calibration coefficients.
- Complete the form with the operator's signature in the "Signature" field on Page 3 at the time work was performed. Route the form for review.

14.0. Appendix B - Diagrams

14.1. 2B Tech. Model 211 Interior Top View

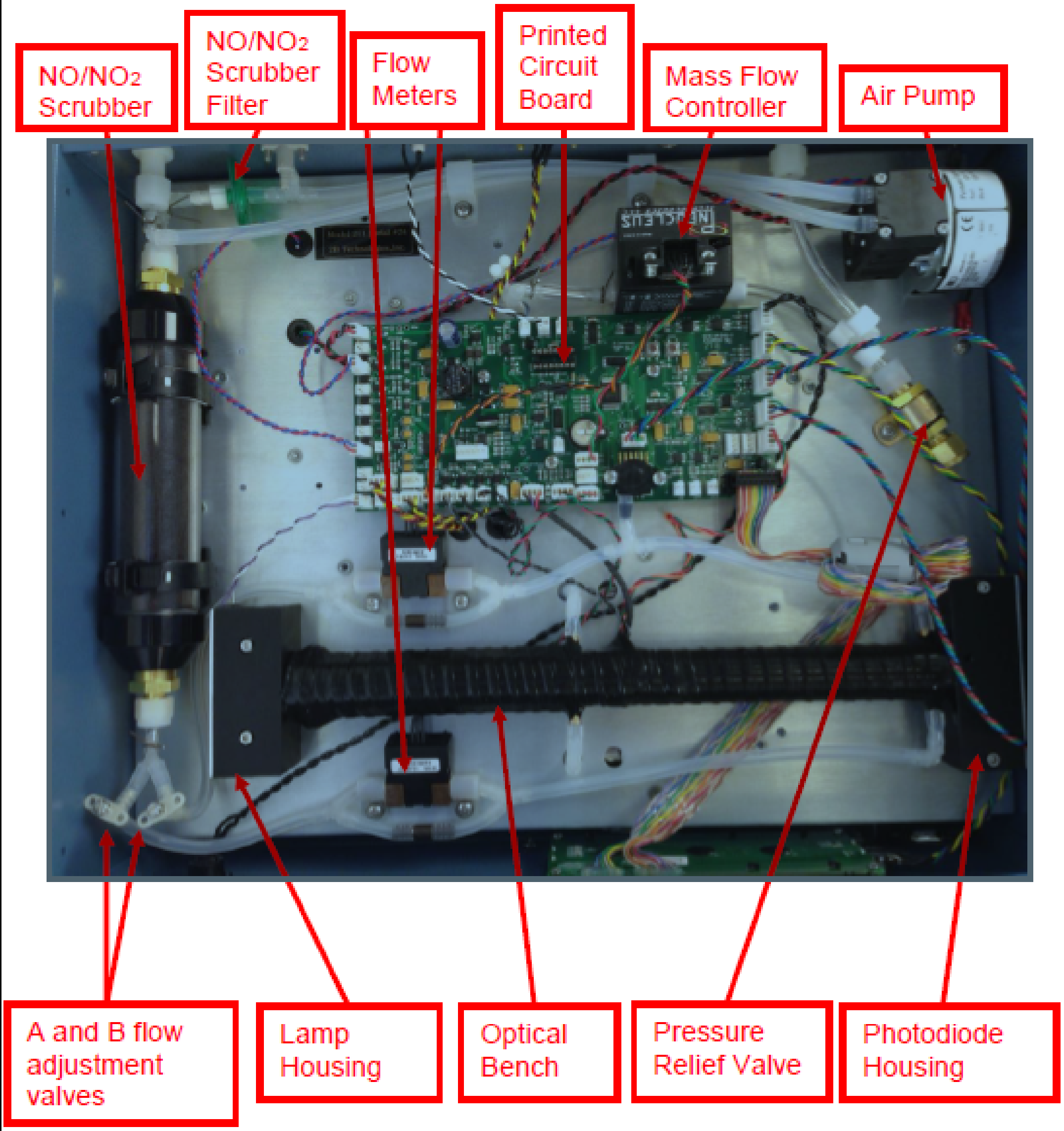


FIGURE 10.1. ***Top view of Model 211 Ozone Monitor with cover removed.***

14.2. <u>2B Tech. Model 211 Interior Bottom View</u>

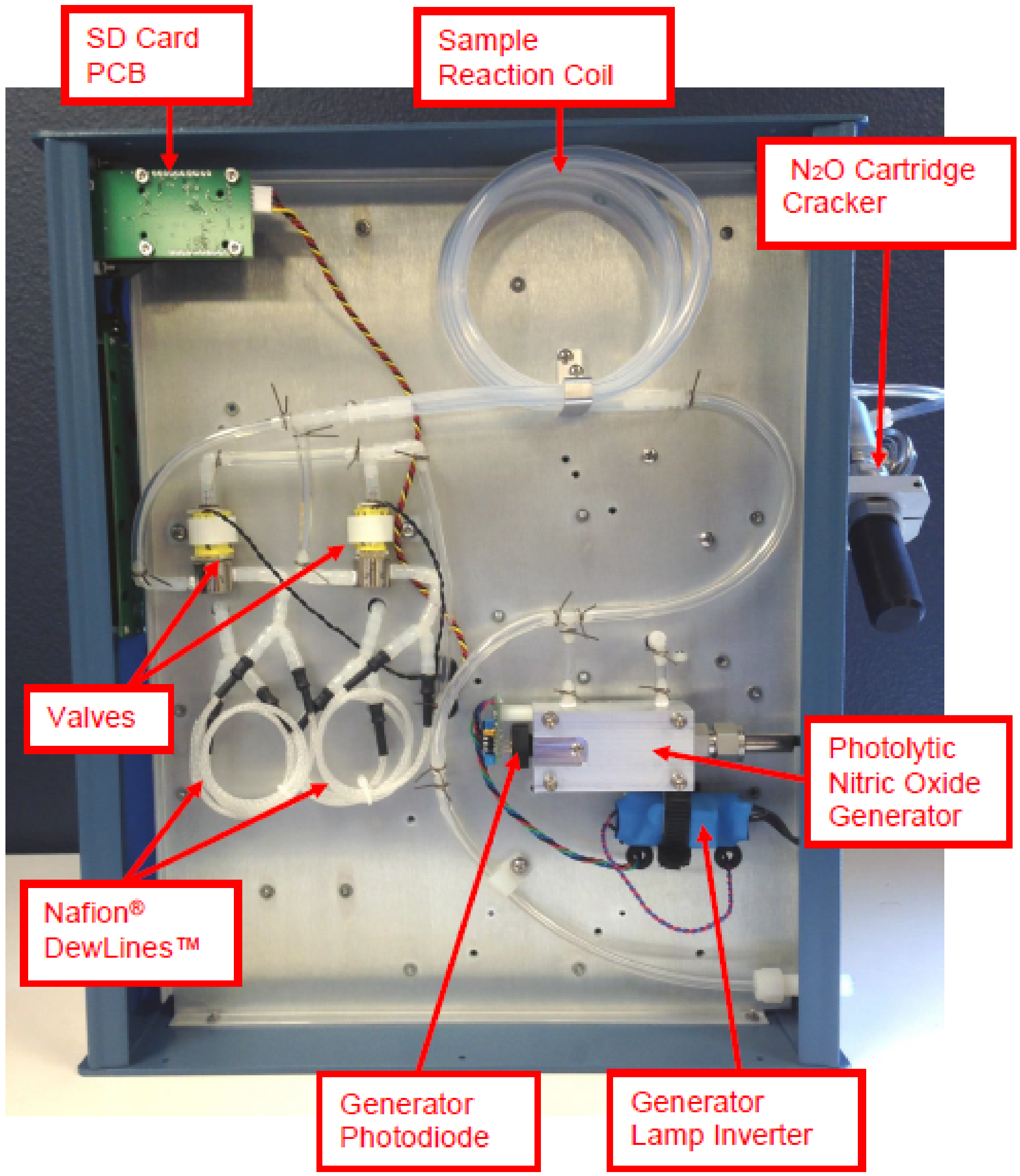


FIGURE 10.2. ***Bottom view of Model 211 Ozone Monitor with cover removed.***

14.3. 2B Tech. Model 211 PC Board

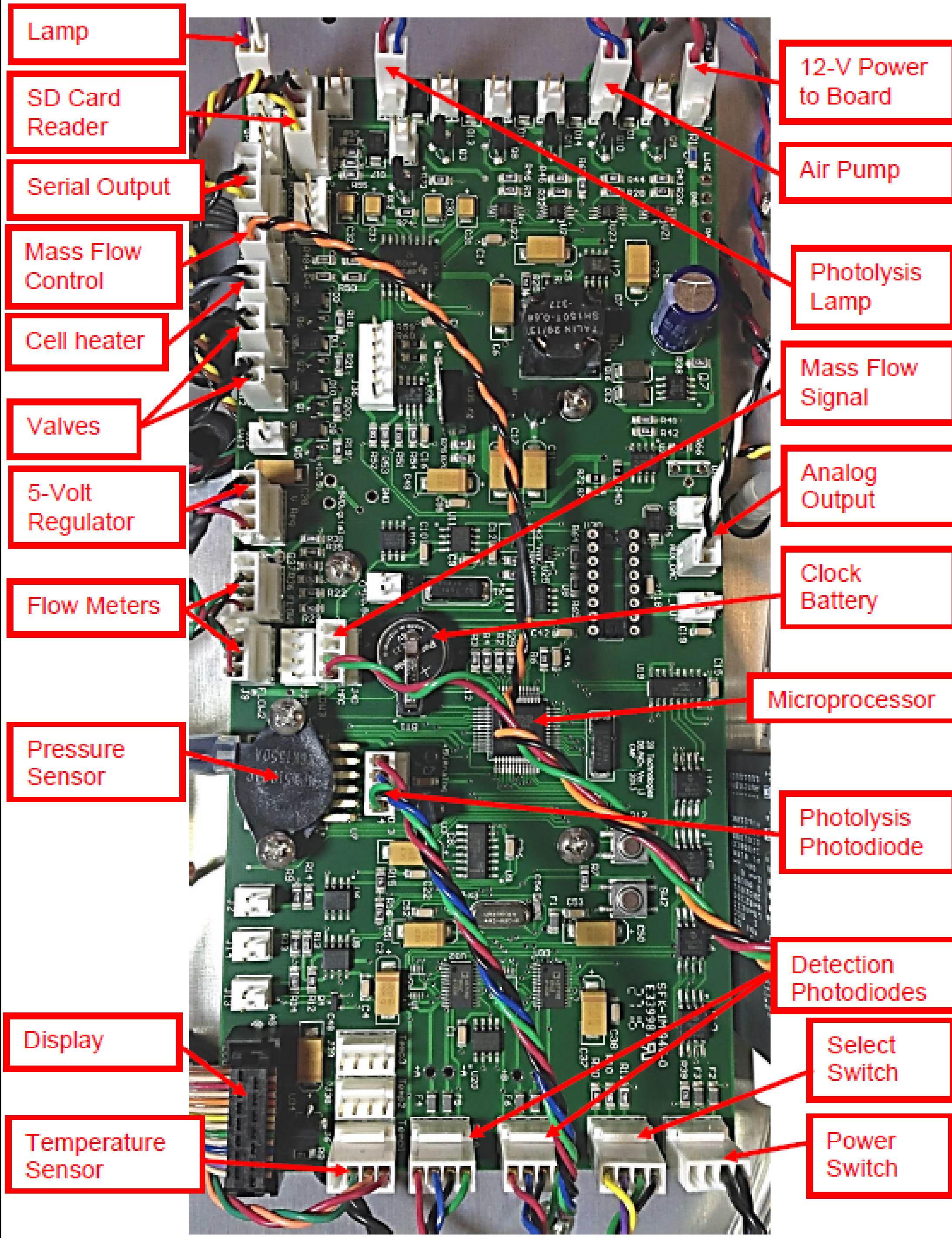
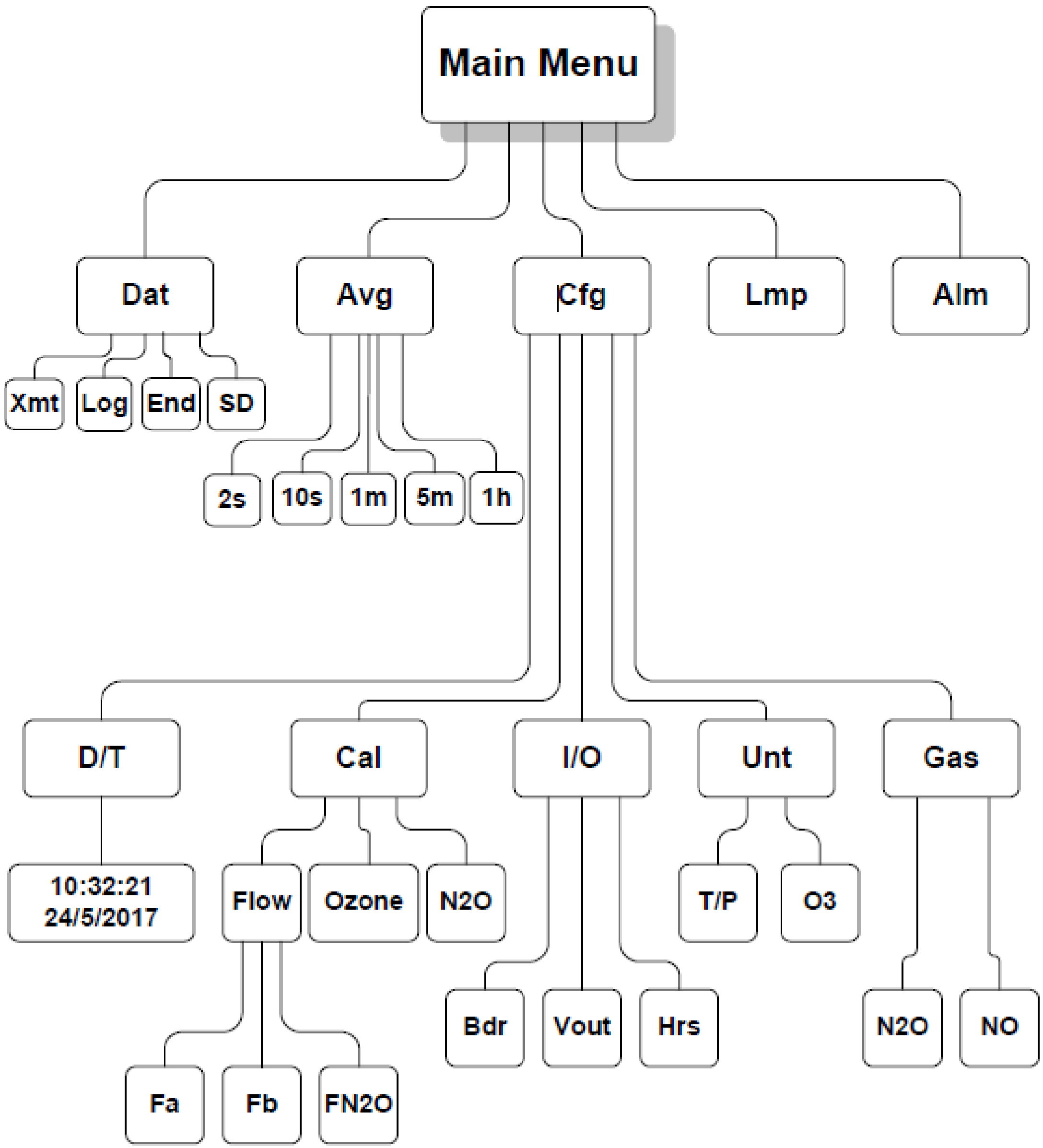


FIGURE 10.3. Printed Circuit Board of the Model 211 Ozone Monitor.

14.4. 2B Tech. Model 211 Menu Tree



14.5. <u>2B Tech. Model 211 O_3 Monitor Configuration</u>

Main Menu*

Avg - Averaging Time Menu

Avg: Averaging Time (always set to 1 Minute)

Cfg – Configuration Menu

D/T – Date/Time Submenu

D/T: Current date and time (24H time, always use EST)

Cal – Calibration Factor Submenu

Fm – Flow Meter Calibration Factor Submenu

Fm: Flow meter calibration factor (factory set)

O_3 – Ozone Calibration Factor Submenu

Z: Computed zero offset (- 10 to 10 ppb) from calibration
S: Computed slope factor (0.90 to 1.10) from calibration

I/O – I/O Controls Submenu

BDR – Baud Rate Submenu

Bdr: Baud rate for serial output (19200)

LCD – LCD Backlight Submenu

Lcd: Backlight switch (On)

Unt – Unit Submenu

T:K – Temperature Pressure Unit Submenu

T:K: Temperature unit of measurement (C)
P: Pressure unit of measurement (torr)

O_3 - Ozone Unit Submenu

O_3: Ozone unit of measurement (ppbv)

* *Configuration settings not listed do not affect Florida PQAO operation*

14.6. 2B Tech. Model 211 O_3 Monitor Front Panel

14.7. 2B Tech. Model 211 O_3 Monitor Rear Panel

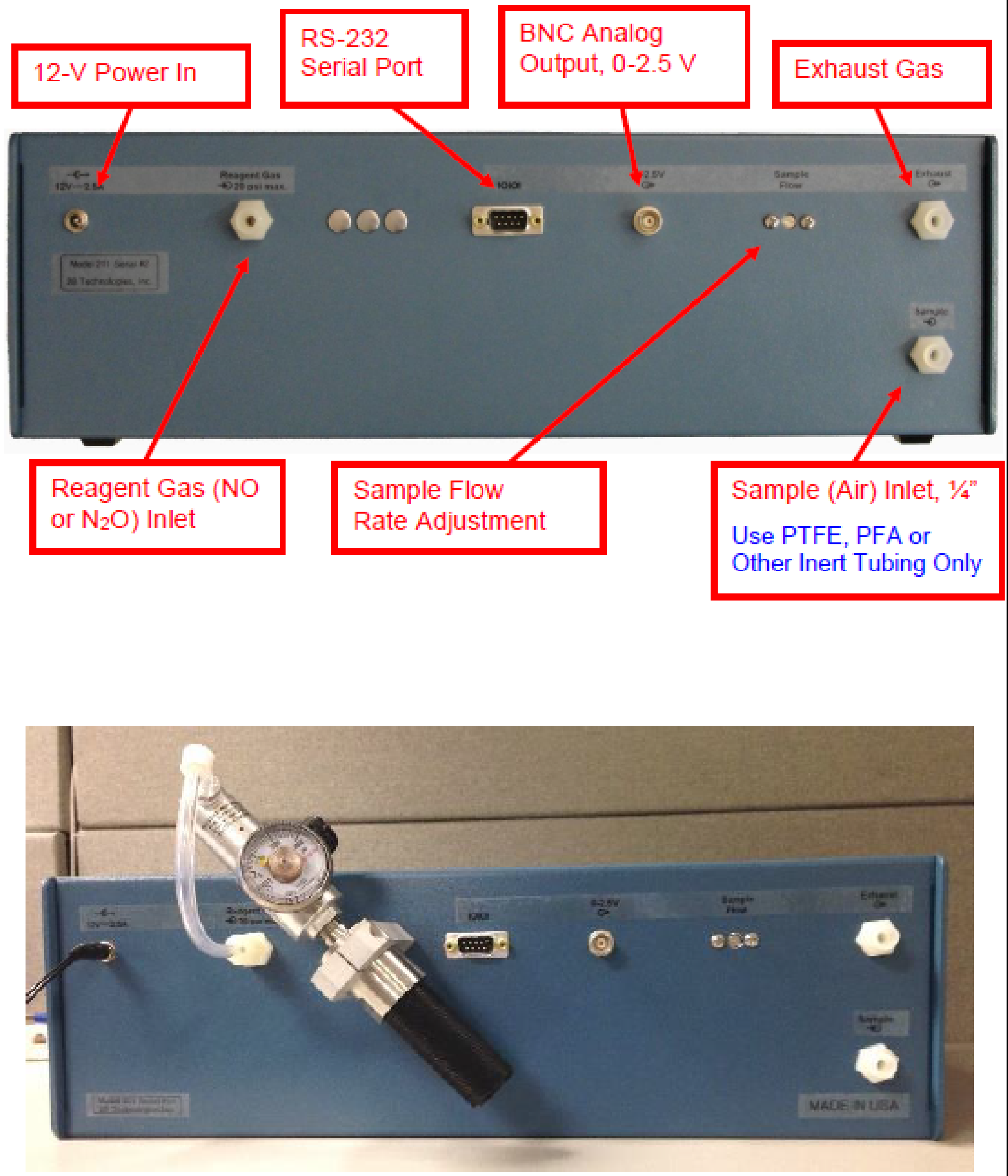
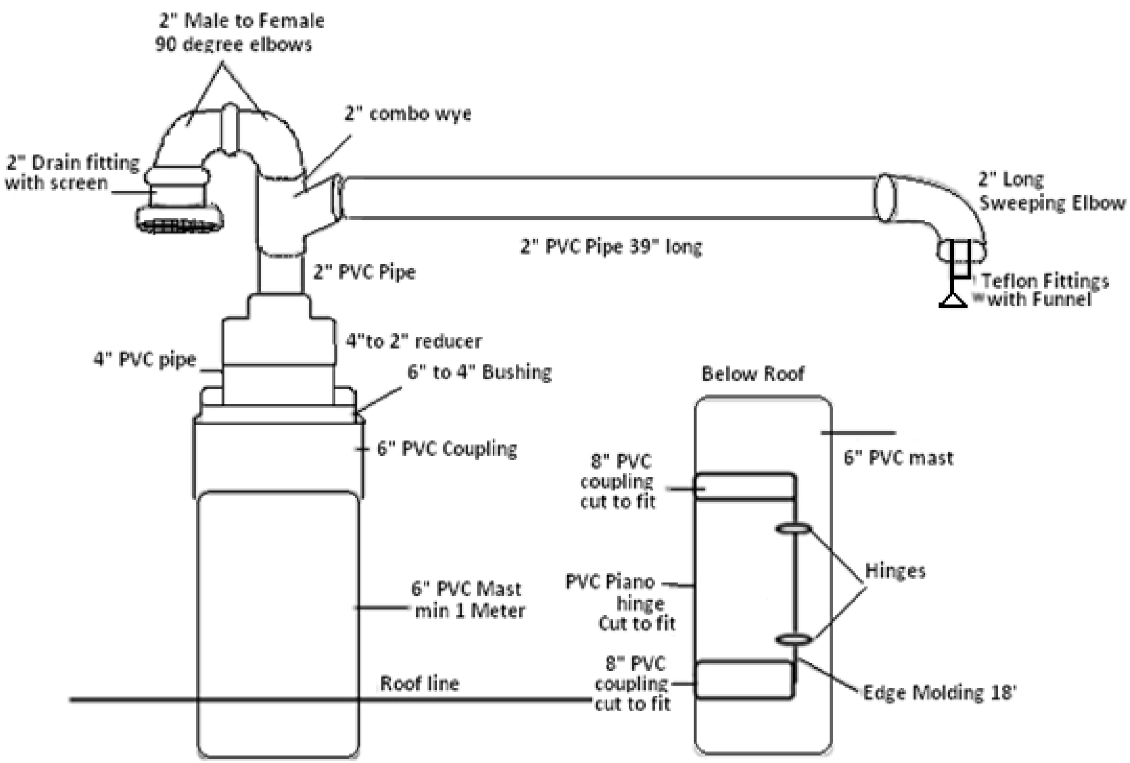
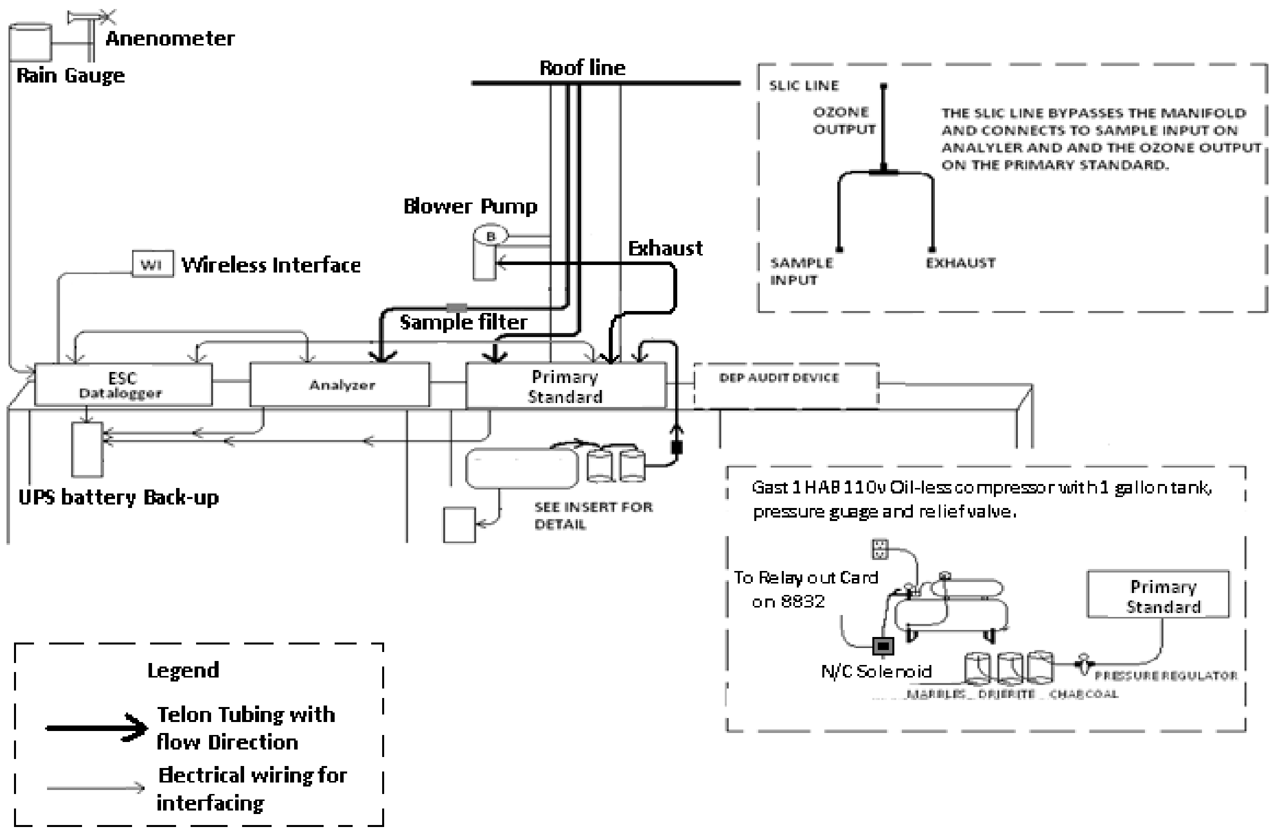


FIGURE 10.4.
Top: *Back of Model 211 Ozone Monitor.*
Bottom: With the N_2O Cartridge Cracker in place.

14.8. Single Line Input Arm Diagram



14.9. Station Layout



15.0. Annual Schedule for QA/QC Tasks

Parameter	Description	Frequency
Filter Check	Filter performance Flow >700 cc/min and or cell pressure not more than 20 torr below ambient barometric pressure	Monthly
Ambient Temperature	Check ambient temperature. **Note:** the shelter temperature requirement is (20°C to 30ºC)	Monthly
SLIC Check	A SLIC is to be performed no less than at quarterly intervals and is encouraged to be performed before and after a filter change.	Quarterly
Filter replacement	Filter replacement is to be done no less than at quarterly intervals.	Quarterly
Zero Air pack reconditioning	Check indicating silica for replacement. Indicating color change of more than 90% at any time is required to be changed.	Quarterly
Time Clock	Check analyzer time clock against a data logger	Quarterly
Lamp Check	Lamp voltage check (0.7-2.5V)	Semi-Annual
Replace Sample line	Replace sample line	Annually
Replace SLIC line	Replace SLIC line	Annually
Logger inspection / concordance check	Data logger inspection for instruments cleanliness connection integrity, and logger concordance with instrument recordings (serial and analog data, time)	Annually
Flows	Verify output flows of analyzer using a NIST certified flow standard	Annually
Pressure sensor	Compare pressure sensor to certified pressure standard. (2B model 211 has no adjustment for pressure, comparison is only requirement)	Annually
Temperature sensor	Compare temperature sensor to certified temperature standard. (2B model 211 has no adjustment for temperature, comparison is only requirement)	Annually
Calibration	Calibration procedure to be performed with certified Ozone standard	Annually
FDEP Comparison	An audit comparison to be performed with certified standard	Annually
Station Ground Test	Perform electrical grounding system test	Annually

16.0. Glossary

2B Tech.	2B Technologies, Inc.
BKG	Background
COEF	Coefficient
DARM	Division of Air Resources Management
DEP	Department of Environmental Protection
DHCP	Dynamic Host Configuration Protocol
ESC	Environmental Systems Corporation
FAMAS	Florida Air Monitoring Assessment System
FDEP	Florida Department of Environmental Protection
FEM	Federal Equivalent Method
L/min	Liters per Minute
Mask	A set of network numbers that can be used to identify the subnet to which an IP address belongs
OAM	Office of Air Monitoring
PC	Personal Computer
PCB	Printed Circuit Board
PM Schd.	Preventive Maintenance Schedule
PM	Preventive Maintenance
PS	Primary Standard
Sec	Second
SI	International System of Units (*Système international d'unités*), the modern metric system
SOP	Standard Operating Procedure
TS 49i-PS	Refers to the Thermo Scientific Model 49i Primary Standard