

## Model 211-G Ozone Monitor™

*EPA Federal Equivalent Method (FEM) for O<sub>3</sub>*



The new Model 211-G Ozone Monitor uses the proven ultraviolet (UV) absorption method in combination with our patented heated graphite scrubber technology ([U.S. Patent No. 10,295,517](http://www.uspto.gov/patents/publications/201501295517)) to measure ozone virtually free of interferences. The instrument is ideally suited for measurements of ozone in heavily polluted air where interferences are likely from particulates, mercury, and/or VOCs. The Model 211 combines the stability of our proven dual beam ozone monitors with our selective scrubber technology to provide accurate ozone measurements in the most polluted air. The enhanced optical path length of 30 cm provides a precision of better than 0.5 ppb for 10-second measurements, and the instrument can output new ozone measurements as often as every 2 seconds. The Model 211-G comes with SD flash card memory as a standard feature. The Model 211-G Ozone Monitor has been designated by the EPA as a Federal Equivalent Method (FEM) as a modification to our Model 211 Scrubberless Ozone Monitor: [EQOA-0514-215](http://www.epa.gov/epaosr/qaqc/eqoa-0514-215)

For the most accurate ozone measurements with virtually zero interferences, we recommend our Model 211 Scrubberless Ozone Monitor. However, the Model 211-G offers the ability to measure ozone in heavily polluted urban air with negligible interferences without the use of the nitrous oxide source required by the Model 211. Use of either the Model 211 or Model 211-G in place of conventional ozone monitors has the potential to bring many regions into compliance with the new national ambient air quality standard simply by making a more accurate measurement.

## Theory

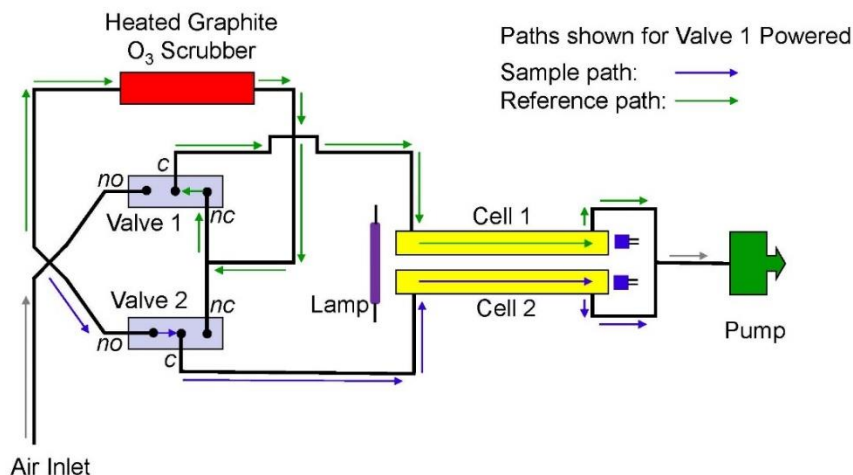
Ozone monitors based on UV absorbance measure ozone by comparing the transmission of light through a detection cell. Light intensity measurements are made with ozone present ( $I$ ) and with ozone removed ( $I_0$ ), and the ozone concentration is calculated using the Beer-Lambert Law. Conventional ozone monitors remove ozone for the  $I_0$  measurement by passing the sample air flow through a solid-phase scrubber (e.g., hopcalite or a series of metal oxide screens). Ideally, the solid-phase scrubber would destroy ozone but pass mercury and other UV-absorbing compounds. In that case, the values of  $I$  and  $I_0$  would be reduced by the same amount, and the

interfering compounds would not affect the ozone measurement. In practice, however, mercury and aromatic compounds such as benzene, toluene, xylenes, phenols, etc. either adsorb or react at the solid-phase scrubber surface. As a result, conventional ozone monitors may report erroneously high ozone values by up to a few ppb on highly polluted days and possibly cause a region to be out of compliance with the EPA's ozone standard. The 2B Tech Model 211-G Ozone Monitor greatly reduces interferences from UV-absorbing compounds and mercury by use of a patent-pending heated graphite scrubber composed of graphite tubes heated to a temperature of  $\sim 130^{\circ}\text{C}$ . At the hot graphite surface, ozone reacts to form gas-phase CO and  $\text{CO}_2$ , the surface being constantly refreshed with underlying carbon. The high temperature prevents significant quantities of VOCs and mercury, which absorbs  $\sim 1,000$  times greater than ozone, from adsorbing and being removed from the air stream.

Like our Model 205 Ozone Monitor, the Model 211-G is dual beam, with a measurement of the transmission of UV light through ozone-scrubbed air being made simultaneously with a measurement of UV light passing through unscrubbed sample air, thus increasing the precision and baseline stability of the instrument.

The Mode 211-G allows remote instrument operation via RS-232, choice of averaging time (2 s to 1 hr), analog voltage output (0-2.5 V), optional analog current output (4-20 mA), and an internal data logger. Our data display and graphing software allows continuous display of data which can be saved for offline analysis.

## Schematic Diagram



## Features

- Measurement of ambient ozone with [patented heated graphite scrubber technology](#) to greatly reduce susceptibility to interferences from other UV-absorbing species such as aromatic VOCs and mercury
- [DewLine™](#) for elimination of water vapor interference, a unique feature of 2B Tech instruments
- Inexpensive, simple, and robust instrument design in a 19" rack mount enclosure
- Internal data logger
- SD flash memory for virtually unlimited portable data storage
- Dual beam, long path (30 cm) optical bench with high precision ( $< 0.5$  ppb)
- NIST-traceable calibration (calibration suggested annually)
- Internal long-life sample pump (15,000 hours)
- EPA Federal Equivalent Method (FEM) for compliance monitoring (EQOA-0514-215)
- Convenient user interface, including remote operation via RS-232 communication

## Options

- Battery
- External particle filter
- Lamp heater for outdoor operation in extreme environments
- Bluetooth wireless data transmission
- 4-20 mA analog current output
- External serial-to-USB adapter
- High-altitude upgrade allows operation up to 25 km (pressure sensor)

## Specifications

<b>Measurement Principle</b>	UV Absorbance at 254 nm; Dual Beam
<b>Federal Equivalent Method (FEM)</b>	Yes, EQOA-0514-215
<b>Ozone Scrubber Technology</b>	Heated graphite scrubber ( <a href="#">U.S. Patent No. 10,295,517</a> )
<b>Linear Dynamic Range</b>	0-500 ppb
<b>Resolution</b>	0.1 ppb
<b>Precision (1<math>\sigma</math> rms noise)</b>	Greater of 0.5 ppb or 1% of reading for 10-s average
<b>Accuracy</b>	Greater of 1.0 ppb or 2% of reading
<b>Limit of Detection (2<math>\sigma</math>)</b>	1.0 ppb for 10-s average
<b>NIST-Traceable Calibration</b>	Yes
<b>Flow Rate (nominal)</b>	~2 Liter/min
<b>Flow Rate Requirement</b>	>1.2 L/min
<b>Baseline Drift</b>	< 1 ppb/day < 3 ppb/year
<b>Sensitivity Drift</b>	< 0.5%/day < 3%/year
<b>Response Time, 100% of Step Change</b>	20 s for 10-s averaging; 4 s for 2-s measurement
<b>Measurement and Averaging Times</b>	2 s, 10 s, 1 min, 5 min, 1 hr
<b>Internal Data Logger Capacity</b>	16,383 lines (10-s avg. = 1.9 days; 1-min avg = 11 days; 5-min avg = 1.9 mo; 1-hr avg = 1.9 yr)
<b>SD Card Logger Capacity</b>	Minimum 2 GB (> 5-year capacity for 10-s measurement mode)

<b>Ozone Units</b>	ppb, ppm, pphm, $\mu\text{g m}^{-3}$ , $\text{mg m}^{-3}$
<b>Pressure Units</b>	mbar, torr
<b>Temperature Units</b>	°C, K
<b>T and P Corrected</b>	Yes
<b>Operating Temperature Range</b>	10 to 50 °C
<b>Operating Altitude Range</b>	~0-13.5 km (150-1,013 mbar) standard; optional ~0-25 km (30-1,013 mbar) with upgraded pressure sensor
<b>Power Requirement; Supplied by Battery or 110/220 VAC Power Pack</b>	11-14 V dc or 120/240 V ac, 1.8 A at 12 V, ~22 watt
<b>Size</b>	Rackmount: 17" w x 14.5" d x 5.5" h (43 x 37 x 14 cm)
<b>Weight</b>	13.4 lb (6.1 kg)
<b>Data Outputs</b>	RS232, 0-2.5 V Analog, optional 4-20 mA Analog, optional USB adapter
<b>Data Transfer Baud Rates</b>	2400, 4800, 19200
<b>Output Ranges</b>	User-Defined Scaling Factor in Menu
<b>DewLine™</b>	Yes
<b>Long-Life Pump</b>	Yes, 15,000 hr
<b>Flow Meter</b>	Yes
<b>Options</b>	Battery; External Particle Filter; Bluetooth; External Serial-to-USB Adapter; 4-20 mA Current Output; Lamp Heater; High-Altitude Upgrade (pressure sensor)

## System Includes

- Model 211-G Ozone Monitor
- AC Power Adapter (100-240 VAC to 12 VDC) with Country-Specific Plug
- Zeroing Cartridge
- SD Card and Card Reader
- Operation Manual on USB Stick
- Calibration Data and NIST-Traceable Calibration Certificate
- Instrument Birth Certificate
- One-Year Warranty