SRS Tech Note

High Concentration Ozone Measurements

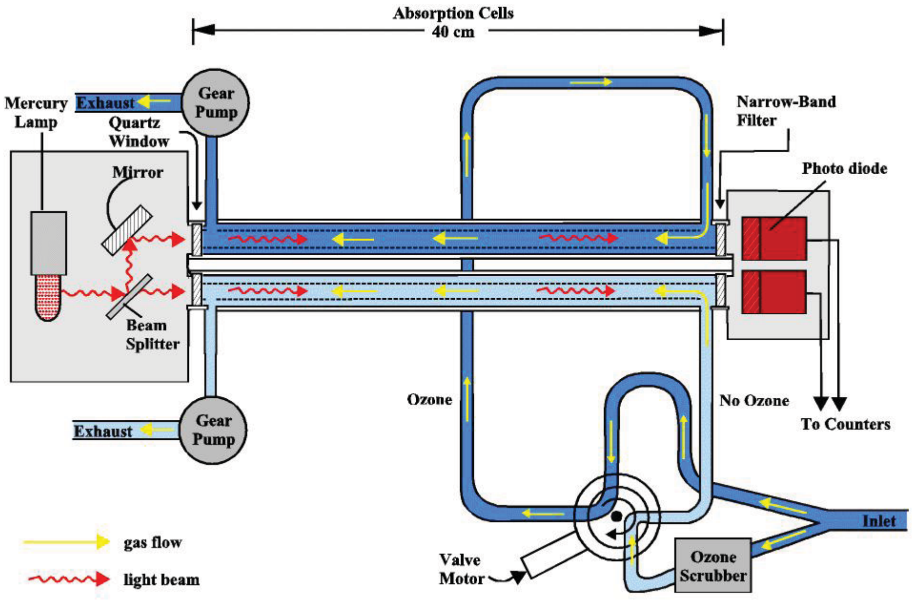
Ozone (triatomic oxygen or O_3) is a very strong oxidizer. Industrial applications for ozone include municipal drinking and wastewater treatment, disinfection of swimming pools and food stuffs, bleaching of wood pulp, semiconductor processing, pharmaceutical manufacture, and chemical synthesis.

Ozone at room temperature decays into diatomic oxygen with a half-life of less than an hour and so it cannot be stored or transported like other gases. Rather, it is made on-site, usually from bottled oxygen or from O_2 concentrated from the atmosphere. A corona discharge is used to dissociate the O_2 into atomic oxygen, some of which recombines with O_2 to form O_3.

Ozone generators vary widely in their performance depending on their design, corona current density and spatial distribution, purity of their oxygen source, pressure, and flow rate. Many applications require a real-time measurement of the ozone concentration to verify the generator's operation and assure the correct amount of ozone is being delivered to the customer's process.

Conventional ozone concentration monitors use the absorption of ultraviolet light to measure the presence of O_3. An emission line at 254 nm from a mercury discharge lamp, which is nearly coincident with a UV absorption wavelength in O_3, is used as the source. The attenuation of the light depends on the path length and ozone concentration (Beer-Lambert Law) allowing computation of the O_3 concentration.

An outstanding example of this technology (for very low concentrations of ozone) is shown below. The NOAA Dual-Beam UV Absorption Ozone Photometer has been used to measure atmospheric ozone on hundreds of flights since the 1980's. (High concentration measurements would use a much shorter path length.)



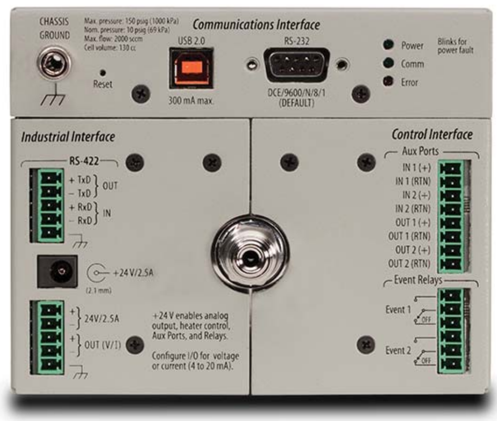
NOAA Dual-Beam UV Absorption Ozone Photometer

There are a few problems with the UV absorption technique: The finite lifetime of the discharge lamp, the need for periodic re-calibration, significant sources of measurement error (including a first-order dependence on pressure), regulatory issues around mercury, and an overall high cost of ownership. These problems have discouraged the adoption of real-time monitoring of ozone concentrations.

A New Approach

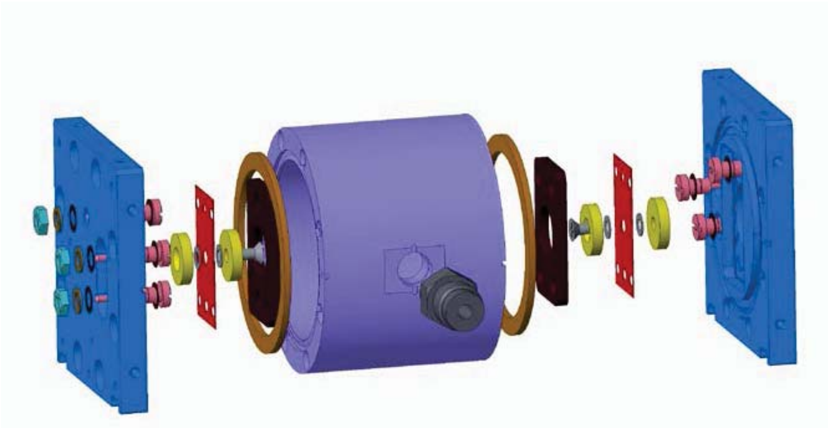
A new binary gas analyzer (top and side views shown below) from Stanford Research Systems takes a very different approach to the measurement of ozone in oxygen: The BGA244 determines the concentration of O_3 by measuring the temperature and the speed of sound in the gas from the ozone generator. Since the mass of O_3 is 50% larger than that of O_2, the speed of sound is substantially lower. By knowing the molar masses of two gases, together with other thermodynamic properties, the BGA244 is able to compute the concentration of ozone with an accuracy of 0.1% and a precision of 0.001%.

BGA244 Top view with touch screen GUI



BGA244 Side view (with Option 1)

The BGA244 determines the speed of sound by measuring the resonant frequency of a gas filled stainless steel cylindrical cavity (exploded view shown on the next page). Planar acoustic transducers (shown in red) positioned between powerful magnets (shown in yellow) excite and detect the cavity's acoustic resonances. Electrical feed throughs provide gas tight connections to the transducers and thermistors. The resonant frequencies can be measured with parts-per-million resolution, enabling very accurate determinations of binary gas compositions (in this case, O_2 and O_3).



BGA244 Acoustic Cavity

Conclusion

The BGA244 provides several advantages when compared to UV photometers: The instrument has no discharge lamp or other wear-out mechanisms. The measured concentration is independent of the pressure. Unlike UV photometers, a thin film of grime will not affect the measurement. Hence no periodic calibration is required. In addition to O_3/O_2 ratio measurements, the BGA244's gas tables list 500 gases allowing the measurement of tens of thousands of binary gas mixtures. Finally, the instrument can provide continuous measurement results, four times a second, via analog outputs (4-20 mA, 0-5 V, or 0-10 V) and RS232, RS422 and USB computer interfaces.

BGA244 Abridged Specifications for Ozone Measurement

Measurement range	0-100% (Mole or mass fraction)
Measurement resolution	0.001% (10 ppm)
Measurement accuracy	0.1%
Measurement accuracy (Rel'd)	0.01%
Measurement speed	4 Hz
Cavity volume	130 cc
Operating pressure	0.5 to 10 Bar
Proof pressure	>100 Bar
Flow rates	0 to 5 LPM
Gas connection	¼" VCR (Welded version recommended for O_3)
Standard communications	USB and RS232
Dimensions	5.5" wide x 4.5"high x 3.25" deep
Power	+5 V/ 400 mA via USB

Option 1 adds RS422 serial communications, cavity heaters, event relays, analog inputs and outputs (4-20 mA, 0-5 V, 0-10 V), and requires operation from +24 Vdc.