# Spectroscopic Determination of Trace Contaminants in High-purity Oxygen

***Steven D. Hornung,*** *White Sands Test Facility*

Oxygen used for extravehicular activities (EVAs) must be free of contaminants because a difference in a few tenths of a percent of argon or nitrogen content can significantly reduce available EVA time. These inert gases build up in the extravehicular mobility unit because the gases are not metabolized or scrubbed from the atmosphere. Measurement of oxygen purity above 99.5% is problematic; currently, only instruments such as gas chromatographs or mass spectrometers are used to make these determinations. Because liquid oxygen boil-off from the space shuttle will no longer be available to supply oxygen for EVA use, other concepts are being developed to produce and validate high-purity oxygen from cabin air onboard the International Space Station.

Personnel at NASA Johnson Space Center's White Sands Test Facility developed a prototype optical emission technique capable of detecting argon and nitrogen below 0.1% in oxygen. A glow discharge in reduced-pressure gas is used to produce atomic emission from the species present. Because the atomic emission lines from oxygen, nitrogen, and argon are discrete and, in many cases, well separated, trace amounts of argon and nitrogen can be detected in the ultraviolet and visible spectrum.

A glow discharge is plasma formed in a low-pressure (1- to 10-Torr) gas cell between two electrodes. Depending on the configuration, voltages ranging from 200 V and above are required to sustain the discharge. The gas is ionized in the discharge region, and a certain population is in the excited state. Light is produced by transitions from the excited states formed in the plasma to the ground state. The spectrum consists of discrete, narrow-emission lines for the atomic species and broader peaks that may appear as a manifold for molecular species such as oxygen and nitrogen, the wavelengths and intensities of which are a characteristic of each atom. Glow discharge spectra of oxygen, nitrogen, and argon are shown in figure 1. In a mixture of gases at a fixed pressure, the intensity of lines in the spectrum depends on the concentration of gas, total pressure of the system, and discharge current through the plasma.

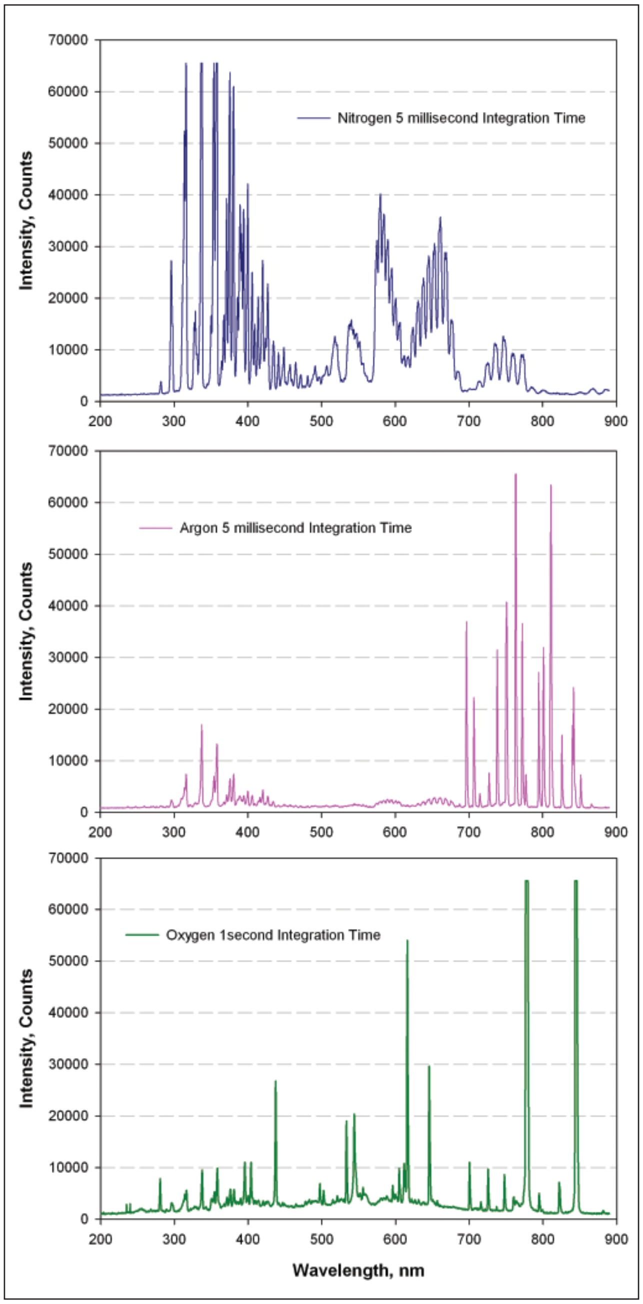


***Fig. 1.*** *Reference glow discharge emission spectra for pure nitrogen, argon, and oxygen taken at 1.3 Torr.*

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The prototype optical emission system (figure 2) uses a quartz capillary tube with stainless-steel end fittings to form the glow discharge tube. The sample gas is introduced into the glow discharge cell using an adjustable vacuum leak valve. From the glow discharge cell, the sample gas passes a vacuum gauge, the downstream valve, and then the vacuum pump. During operation, the pressure in the glow discharge cell is maintained between 0.5 and 10 Torr using the adjustable leak valve and the downstream valve. In proof-of-concept testing, the discharge power was supplied by a 5-kV AC [alternating current], 10-mA power supply. Light from the discharge is collected by a lens and coupled to a ultraviolet-visible fiber-optic cable. This cable directs the light from the glow discharge into a spectrometer. The spectrometer detects in the 200- to 850-nm region with a spectral resolution of 1.5 nm using a 25-µm entrance slit. The spectrometer is connected to a data acquisition computer via a USB [Universal Serial Bus] cable.

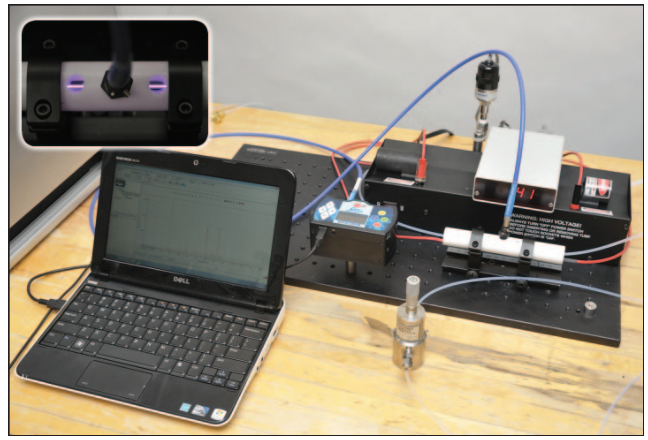

***Fig. 2.*** *Prototype system with inset showing glow discharge region.*

This work represents a proof-of-concept investigation into using a glow discharge emission system to detect and quantify trace amounts of argon in pure oxygen. A similar analysis will need to be done for nitrogen. Straightforward, direct measurement of these target contaminants may lend itself to a device that is capable of on-orbit verification of oxygen purity.