

# SRS Tech Note

## BGA244 Application Note Monitoring Gas Quality in Helium Recovery Systems Stanford Research Systems

Helium is a non-renewable resource. More than 30 million cubic meters are used annually. Supply, cost, and environmental concerns are driving the adoption of helium recovery systems, especially in cryogenic and heat-quenching applications.

A helium recovery system consists of low pressure plumbing for the post-process recovery, a low pressure collection bag, compressors and holding tanks. A gas purification system is used to remove unwanted air and water from the compressed helium. Cryogenic applications may include an on-site liquefier and liquid helium cryostats.

A helium recovery system also has instruments to monitor the purity of the helium recovered from the process, and the purity of the compressed gas. Previously, this has been done by measuring the thermal conductivity of the gas: Helium has a very high thermal conductivity compared to air or water vapor and so can be used as a gauge for the purity of the recovered helium.

Unfortunately, thermal conductivity gauges have large offset errors and their calibration drifts over time (typically by 0.5%/week). They also require minimum flow rates and are only calibrated over narrow pressure ranges.

### Process Gas Analyzer

A new process gas analyzer from SRS, the BGA244 Binary Gas Analyzer, determines the purity of gases by measuring the temperature and speed of sound in the gas. The temperature is measured with millidegree resolution, and the speed of sound is determined from the resonant frequency of the gas in a cylindrical cavity. This enables the determination of the gas composition with an accuracy of better than 0.01%, and resolution of a few ppm, with virtually no calibration drift (less than 10 ppm/year).



## Measuring air in helium

The speed of sound at NTP is about 1007.934 m/s in helium and about 343.36 m/s in dry air. The BGA244 is able to measure the speed of sound with 0.001 m/s resolution. The BGA244 can compute the speed of sound in mixtures, inclusive of mixing rules and temperature dependencies of heat capacities, virial effects, etc. The BGA244 determines the composition of the mixture by finding that composition which yields the measured speed of sound.

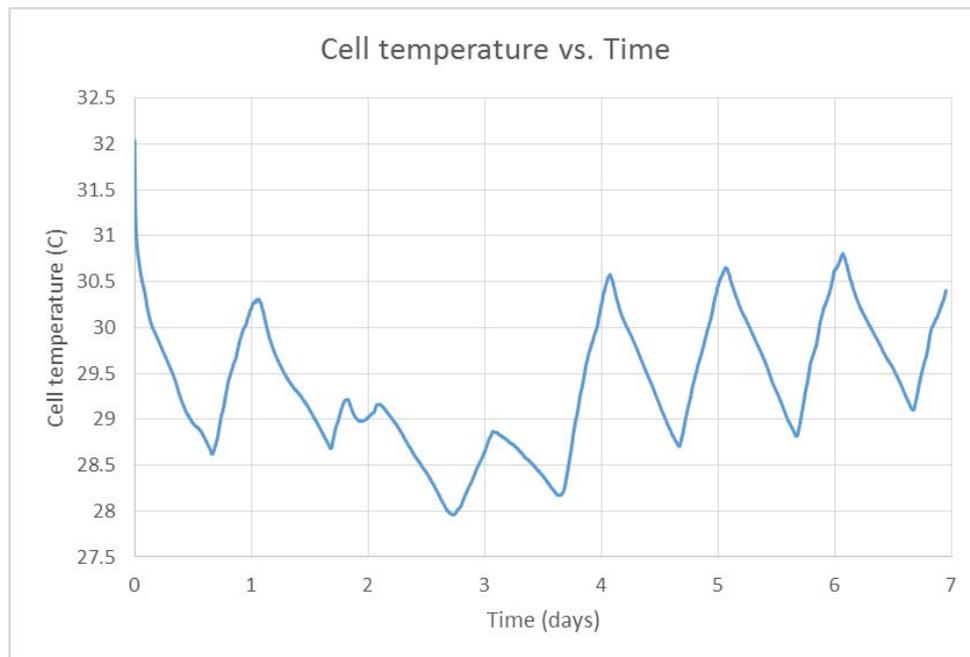
The technique works very well for helium, where small changes in composition create large changes in the speed of sound. Results (below) show a measurement error of only 20 ppm in the mole fraction of air in a sample of pure helium.

## Experiment

A trial was designed to examine the accuracy and stability of the BGA244 for detecting air in helium. A calibrated BGA244 was filled with helium to +5 psig, closed off, and operated for a week. (The same results are expected had the helium been flowing through the cell at rates up to 5 lpm or at pressures from 0 to 150 psig.) The instrument was configured to average the data over 10 measurement intervals, which is about 2.3 seconds. Data was collected from the instrument via its USB interface, analyzed in Excel, and is presented below. (In addition to USB, the BGA244 also has RS232, 4-20 mA and 0-10 V interfaces.)

## Results

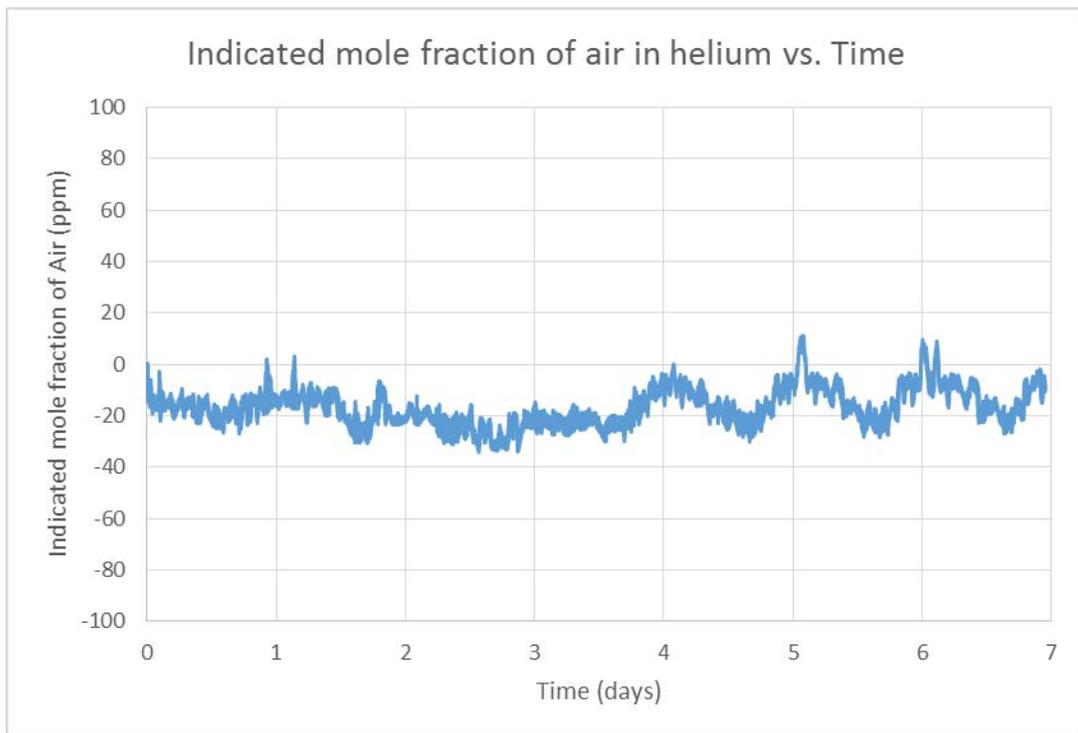
The BGA244 was operated without using the cell heaters to stabilize the gas temperature, allowing the helium to follow the room temperature. The cell varied from 28°C to 31°C over the seven day period as shown below:



## Mole fraction of Air

The graph below shows the indicated mole fraction of air in helium over the seven days. Using the 'as-shipped' calibration (i.e., not using the Rel function) the instrument indicated about -20 ppm mole fraction of air in the pure helium sample. (The negative offset of 20 ppm indicates that the instrument measured a speed of sound slightly above what was expected for pure helium. This small calibration error could be eliminated using the Rel feature of the instrument.)

Analysis shows a small temperature dependence of about +8 ppm/°C, however there is no apparent drift in the calibration over time. There is noise of about 10 ppm, peak-to-peak, which could be reduced with additional averaging.



## Conclusion

The BGA244 can be used to accurately measure impurities in helium gas. Measurements taken over one week indicate an offset error in the mole fraction of air of about -20 ppm, a temperature dependence of about +8 ppm/°C, noise of about 10 ppm (peak-to-peak), and no apparent offset drift.