# SRS Tech Note

**Measurement of Argon-Air and Krypton-Air Mixtures for Insulating Windows**

## Overview

Double and triple pane windows improve energy efficiency and reduce outside noise in homes and offices. Filling the space between the window panes with argon or krypton improves their performance by reducing thermal conductivity and providing an acoustic impedance mismatch. Filling with a dry, inert gas also eliminates condensation inside the window.

Argon and krypton are inert, odorless, and colorless gases. The heavier, slower (and more expensive) krypton provides better performance, especially in triple pane windows where smaller spacing reduces convective heat transfer between the panes.

Manufacturers of inert gas filled windows can improve their product quality, and reduce their gas consumption, by measuring the gas which leaves the window as the inert gas flows in. The BGA244 Binary Gas Analyzer is ideal for this application, providing better than 1% accuracy in the air/gas concentration measurement.

## Binary Gas Analyzer

The BGA244 determines gas component concentrations in a binary gas mixture by measuring the gas temperature and the speed of sound in the mixture. Then, using thermodynamic data (the instrument has a database for about 500 gases) and the pressure (user-entered or gauge measured), the instrument computes the component concentrations. By including the temperature dependence of heat capacities, and virial effects and their mixing rules, these computations eliminate nonlinearities, to provide accurate measurements from 0-100% concentrations.


**BGA244HP with touch screen display**

The speed of sound at NTP (20˚C, 1 atm) is 343.36 m/s in dry air, 318.890 m/s in argon and 220.174 m/s in krypton. The BGA244 measures the speed of sound with 0.001 m/s resolution by measuring the resonant frequency of an acoustic standing wave in an internal 130 cc stainless steel cavity.

The speed of sound does not increase linearly with the concentration of air in argon/air or krypton/air mixtures. In argon/air mixtures the speed of sound increases by only +0.025 m/s when 1% air is added

to pure argon. The situation in air-krypton measurements is much better, where the speed of sound increases by +0.45 m/s when 1% air is added to pure krypton.

In an ideal gas the speed of sound is independent of pressure. In real gases, virial effects cause the speed of sound to change with pressure. For argon, the speed of sound changes by about +0.005 m/s per psi increase in pressure. In addition, there are artifacts (acoustic transducer resonances and thermo-viscous boundary layers) which are characterized during the instrument's calibration. The BGA244 is able to compensate for all these effects but needs to know the pressure to do so.

**Measurement Uncertainty**

When used as a binary gas analyzer, the BGA244 displays the concentrations of the two gas species along with an estimate of the uncertainty of the measurement. For example, near the end of the window filling process the display may indicate "97.15% Argon in Air" with an uncertainty of ±1.77%. The uncertainty is estimated based on the (estimated) errors of ±0.1˚C (in temperature), ±1 psi (in pressure), and the thermodynamic characteristics of the gas mixture.

The BGA244 is calibrated with argon gas and so the temperature error will be much smaller than 0.1˚C. The dominate source of error will come from the pressure uncertainty. Atmospheric pressure at sea level is about 14.7 psia with typical meteorological variations of ±0.3 psia. Atmospheric pressure also depends on altitude, dropping by about 0.5 psi/1000 feet. In addition, the user's equipment may create pressure deviations from atmospheric in order to get the gas to flow though the instrument.

**Venting to air**

If the gas flow is through the window being filled, into the BGA244, and vented to the room without any significant restrictions, then the operating pressure will be very close to atmospheric pressure. At sea level, manually setting the absolute pressure to 14.7 psia, or the gauge pressure to 0 psig with the ambient pressure set to 14.7 psia, will be accurate to ±0.3 psia which will cause an air concentration error of less than ±0.5%.

**Using a Pressure gauge**

The measurement accuracy can be improved by measuring the pressure of the gas mixture inside the BGA244. An electronic pressure transducer can be connected directly to the BGA244, and the pressure measured at gas inlet. This is particularly important if the application uses a pump to move the gas mixture through the BGA244. Any pumps and restrictions should be arranged so that the BGA244 is operated near atmospheric pressure. If a vacuum pump is used to move the air from the window to the BGA244, a restriction should be placed between the BGA244 and the vacuum pump.

To measure pressure we recommend using a 4-20 mA, 0-30 psia pressure transmitter, such as Omega Engineering's PX209-030AI. Using an absolute pressure gauge will also make the measurement immune to meteorological variations in atmospheric pressure or altitude. This two-wire transmitter can be connected directly to the BGA244, which will provide loop power and measure the gauge current. The BGA244 can convert the measured current into a pressure, and use that measured pressure to correct for virial and instrumentation effects.

**Relative Measurements**

The accuracies and uncertainties discussed above are the “out of the box” specified values. In many circumstances residual errors can be dramatically reduced by using “relative” measurements. In this case, the analyzer is filled with pure argon at the nominal operating pressure and flow rate. The instrument will read something like “99.5% Argon in Air”. The “REL” feature is accessed from the Setup Menu. The user selects “Use Rel”, “Rel to 100%”. In this case a “Rel value” of 0.5% is displayed. Future readings will add this Rel value to the measurement, so, the next time a pure argon stream is passing though the instrument the reading will be “100.0% Argon in Air”, with a typical wandering of about ±0.2% (for argon/air mixtures.)

**Development and OEM versions**

The standard BGA244 has a touch screen display which facilitates instrument setup, lab use and learning. OEM versions are available, at lower costs. Interfaces include USB, RS232, RS422, 0-5V, 0-10V and 4-20mA.


**BGA244 showing interface connection (left) and BGA244 OEM version (right)**

**Conclusion**

Double and triple paned windows filled with argon or krypton provide improved acoustic and thermal insulation. Monitoring the gas filling process during production improves product quality and reduces gas expense. The BGA244 gas analyzer can be used to measure the quality of the gas fill with an “out of the box” accuracy of about 1%. The BGA244 is available in both touch-screen and OEM versions.