SRS Tech Note

BGA244 Gas Purity Mode

The BGA244 characterizes gases by measuring their temperature and speed of sound (SoS). The instrument has three operating modes: The Binary Gas Analyzer mode reports the concentrations of two-component gas mixtures. The Gas Purity mode reports the deviation from the expected SoS for single gas. And the Physical Measurements mode reports the gas temperature, the measured SoS, and the SoS referenced to NTP (20 C and 1 atmosphere).

This Tech Note details the Gas Purity mode. The sensitivity of the Gas Purity mode depends on the difference in the SoS between the Base Gas and its possible contaminants. The table below details several cases. In each case the Base Gas (in rows) is contaminated with 1% of the Added Gas (in columns). The numbers in the tables are the change in the SoS caused by the 1% contaminant, and are indicative of the sensitivity for detecting the contaminant.

Speed of Sound in Gas Mixtures

Interactive analysis of how adding 1% of different gases affects the speed of sound at 20°C (NPT)

Pure Gas Speeds of Sound at 20°C (293.15 K) - NPT

H_2 Hydrogen **1306 m/s**	He Helium **1008 m/s**	CH_4 Methane **446 m/s**	NH_3 Ammonia **433 m/s**	N_2 Nitrogen **349 m/s**	Air Air **343 m/s**
O_2 Oxygen **327 m/s**	Ar Argon **319 m/s**	CO_2 Carbon Dioxide **268 m/s**	SF_6 Sulfur Hexafluoride **135 m/s**		

Percentage Change in Speed of Sound When Adding 1% of Different Gases

Rows: Base gas (99%), Columns: Added gas (1%)

Base Gas \ Added Gas	H_2	He	CH_4	NH_3	N_2	Air	O_2	Ar	CO_2	SF_6
H_2	—	-0.397%	-3.341%	-3.562%	-5.888%	-6.085%	-6.701%	-8.175%	-9.063%	-23.715%
He	0.171%	—	-1.577%	-1.695%	-2.949%	-3.058%	-3.402%	-4.209%	-4.757%	-14.238%
CH_4	0.478%	0.515%	—	-0.031%	-0.337%	-0.366%	-0.460%	-0.601%	-0.864%	-3.903%
NH_3	0.482%	0.523%	0.029%	—	-0.287%	-0.314%	-0.402%	-0.530%	-0.787%	-3.667%
N_2	0.471%	0.528%	0.182%	0.164%	—	-0.017%	-0.071%	-0.116%	-0.320%	-2.151%
Air	0.472%	0.531%	0.192%	0.174%	0.017%	—	-0.052%	-0.093%	-0.294%	-2.070%
O_2	0.475%	0.537%	0.218%	0.202%	0.062%	0.047%	—	-0.028%	-0.223%	-1.845%
Ar	0.400%	0.453%	0.192%	0.180%	0.069%	0.057%	0.019%	—	-0.162%	-1.474%
CO_2	0.523%	0.601%	0.323%	0.312%	0.221%	0.210%	0.175%	0.188%	—	-1.219%
SF_6	0.644%	0.757%	0.549%	0.546%	0.549%	0.546%	0.535%	0.632%	0.448%	—

● Positive: Speed increases ● Negative: Speed decreases ● Diagonal: Same gas (no change)

For example, if helium in the BGA244 were contaminated by 1% of air, the table shows that the SoS would be reduced by 3.058%. Given that the BGA244 reports the measured SoS (automatically referenced to NTP) with 0.001% resolution, a well-settled measurement would have the *precision* to detect a change of 3.2 ppm of air in helium.

Gas Purity mode *accuracy* is improved by filling the BGA244 with a known pure sample, and setting the REL so that the reported SoS deviation is zero. In many process situations, it is sufficient to know that "the gas is the same as last time". This protects against improperly evacuated gas manifolds, failed gas regulators, misbehaving flow controllers, low-grade gas sources, and operator errors.

Clearly, there are situations where the sensitivity to contaminants is much lower than the helium/air case described above. These problematic cases lie close to the table diagonal. For example, 1% O_2 in Ar only increases the SoS by only 0.019%, indicating that the BGA244 may not be useful in such a case. Other techniques would be recommended, such as purpose-built O_2 detectors or mass spectroscopy.

Conclusion

Operating the BGA244 in the Gas Purity mode can provide real-time assurance that a process gas is uncontaminated. The sensitivity of the measurement will depend on the difference in the speed of sound of the Base Gas and potential contaminants.

Appendix

How the numbers were obtained

1. **Pure-gas properties** – Molar masses and 25 °C heat-capacity ratios (γ) were taken from standard data tables. Typical γ values: 1.40 for diatomics (N_2, O_2, air), 1.67 for monatomic nobles (He, Ne, Ar, Kr), 1.30–1.32 for CO_2 and CH_4, 1.41 for H_2.
2. **Ideal-gas formula** – $c = \sqrt{\gamma\, RT/M}$ gives the baseline speed c_0.
3. **1 % mixture** – For a 99 %/1 % binary mixture,
   - $M_{\text{mix}} = 0.99\, M_{\text{base}} + 0.01\, M_{\text{dopant}}$
   - $C_{p,\text{mix}} = 0.99\, C_{p,\text{base}} + 0.01\, C_{p,\text{dopant}}$, $C_v = C_p - R$; then $\gamma_{\text{mix}} = C_p/C_v$.
   - The new sound speed is $c_{\text{mix}} = \sqrt{\gamma_{\text{mix}} RT/M_{\text{mix}}}$.
4. **Percent change** – $\Delta c/c_0 = (c_{\text{mix}} - c_0)/c_0$.

Because only 1 mol % is added, real-gas departures and thermo-viscous effects are much smaller than the changes shown here, so the ideal-gas treatment is adequate for quick estimates.