NASA TECH BRIEF

Langley Research Center

Dynamic Delta Method for Trace Gas Analysis

The problem:

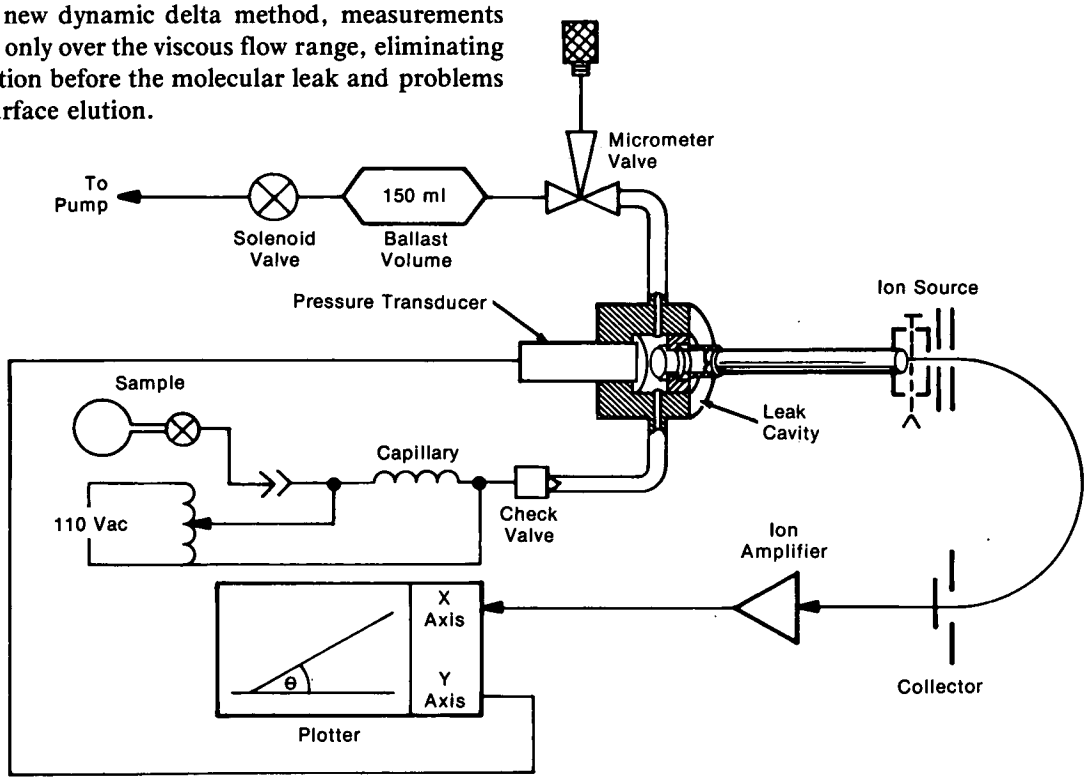
Trace gas analysis by mass spectrometry is limited by instrument background, gaseous elution from internal surfaces, precise pressure measurement, and molecular diffusion-rate differences through the inlet leak. The conventional delta method, in which measurements are made at two different sample pressures, yields a slope function which alleviates the background effects but requires careful determination of all other parameters.

The solution:

In the new dynamic delta method, measurements are made only over the viscous flow range, eliminating fractionation before the molecular leak and problems due to surface elution.

How it's done:

As shown in the illustration, the solenoid valve is closed and a gaseous sample passes through a heated 0.006-in. (0.02-cm) stainless-steel capillary to a leak cavity. The leak cavity contains an unbonded strain-gage pressure transducer and a gold molecular leak. The gas proceeds into a ballast volume. The flow is approximately 1.2 cm^3/min. The sample pressure increases to a final pressure of approximately 3 torr at a constant rate. Measurements are made only over the viscous flow range.



Gas Analysis System

(continued overleaf)

Ion current from the resolved mass specific to the measured gas is plotted on an X-Y recorder as a function of output from the pressure transducer, effectively resulting in an infinite number of data points. The slope of the plot is therefore a direct measure of the partial pressure of the trace constituent being determined. As long as output from the pressure transducer is linear, a determination of absolute pressure is not required.

The concentration of the trace constituent is computed by a comparison of the tangents of the unknown (subscript 1) to a known (subscript 2) concentration. This can be described by

$$\text{Volume (percent)} = \frac{\tan \Theta_1 : \Omega_2 : \mu_1 \cdot 10^2}{\tan \Theta_2 : \Omega_1 \cdot \mu_2}$$

where Θ is the slope angle, Ω is the electrometer input resistance, and μ is the recorder attenuation. The known concentration is obtained by calibration using a standard mixture or the pure gas. Isotopic abundance determinations may also be made as long as standard mass flow corrections for the molecular leak are applied. Resistive heating of the capillary is controlled by a standard autotransformer.

With the equipment shown, a usable measurement range for rare gases in mixtures is from 100 percent (pure sample) to parts per million. Measurement capability is somewhat reduced for certain reactive species. Relative precision over the entire range is approximately 1 percent of the measured value.

Note:

Requests for further information may be directed to:

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Patent status:

NASA has decided not to apply for a patent.

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