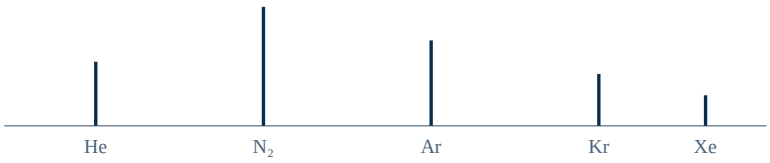
REALMETER • RealMeter Instruments (Shanghai)

POPULAR SCIENCE • RGA • VACUUM METROLOGY

Quantitative Analysis of a Five-Gas Mixture by RGA: RSF Back-Calculation, Operating-Condition Robustness, and Sampling-Geometry Effects

— Popular Science Edition: Giving the Vacuum System's "Eyes" a Trustworthy Scale



Residual gas analyzers (RGAs) are installed on most vacuum tools. They tell the operator which gases are present inside the chamber, and their screens often display partial pressures and ppm readings directly.

This article explains, in plain language, one question behind our study: **what does it take to make those readings trustworthy?** It covers principles, ideas, and significance only; experimental details and specific data are not included.

---

1. Recognizing a gas is not the same as counting it

An RGA works a little like this: it breaks gas molecules into charged fragments and sorts them by mass, producing a spectrum. Different gases have different spectral patterns, just as different people have different fingerprints. That is why an RGA is very good at answering "who is there."

Getting from "who" to "how much," however, requires an extra step. The signal intensity must be multiplied by a conversion factor before it becomes a concentration. This factor is called the relative sensitivity factor (RSF). Think of it as the **scale markings on a weighing balance**.

Here is the catch: an uncalibrated balance produces numbers, not weights. Many concentration readings on RGA screens are calculated using generic factor tables — tables that were never measured on your particular instrument.

2. What we did: testing the balance with a "standard weight"

Our approach was deliberately simple.

First, we prepared a five-gas mixture whose composition was accurately prepared and traceable. We then let it flow into the vacuum chamber through calibrated leak standards at a stable, known rate. A calibrated leak standard plays the role of a **"standard weight" in the vacuum world**.

Next, we let an RGA in routine service measure this gas stream. **We knew what went in; the instrument told us what it read.** Comparing the two gives the instrument's own true conversion factors.

We then added two kinds of comparison. One mimicked everyday operations on a production line — cycling the leak valves, switching the ion-source filament off and on — to see how much the readings moved. The other changed nothing except the gas inlet position, to isolate the effect of mounting geometry.

3. Three qualitative findings

01 **First, a generic factor table should not be used as a scale.** The instrument's true conversion factors deviated clearly from the generic table values, and the direction of deviation was not consistent across gases — some read high, others low. There is no single "discount factor" that fixes everything; trustworthy concentrations can only come from measurements on the instrument itself.

02 **Second, routine operations have relatively limited effects.** Valve cycling and filament restarts do move the readings, and periodic recalibration is needed to track this drift — but they are not the dominant source of error.

03 **Third, mounting position matters far more than most users expect.** Changing only the inlet position produced marked changes in the readings, well beyond the effects of routine operations. The reason is not mysterious: the instrument measures the gas state where its head is located. Measuring wind speed at the outlet and in a sheltered corner gives different answers. Quantitative work therefore has an order of operations: **fix the geometry first, calibrate on the instrument second, and recalibrate periodically after that.**

4. Why this matters for semiconductor processing

The RGA is the most common "eye" on semiconductor vacuum processes. Making its readings trustworthy changes not just the numbers, but the way processes can be improved.

Alarm thresholds become transferable. Today's common practice is to watch relative changes against a historical baseline. That experience is tied to one tool, one chamber, and one plumbing arrangement, and it has to be rebuilt after every major change. Once readings are quantitative, thresholds can travel from one tool to another.

Tools become genuinely comparable. When several identical tools run the same process, which one really has less moisture or a larger leak? Only a shared measuring stick separates process differences from instrument differences.

Process windows can become design values. Process improvement moves from "adjust and see" toward "design by physical quantities." Only a quantified vacuum environment can be written into design rules instead of living in a senior engineer's intuition.

New tools can ramp faster. Experience depreciates as equipment generations change; data can accumulate across generations. A process window verified on an older tool becomes the starting point for a new one, rather than starting from zero every time. For fast-moving equipment and process teams, this is a practical path from "depending on veterans" to "depending on a system."

5. What you can do on the line today

Some improvements need no new hardware:

- Write the head and inlet mounting arrangement into the operating documents, and keep the same arrangement for comparison measurements.
- Separate “watching trends” from “reporting concentrations.” Without in-situ calibration, use readings for trends only.
- Look at background and detection limits together with their measurement conditions; a detection-limit number alone says little.
- Where possible, perform in-situ calibration with calibrated leak standards, and schedule periodic recalibration.

Conclusion

The RGA does not lack precision potential; it lacks a trustworthy anchor. The anchor itself is not new — calibrated leak standards have served helium leak detector calibration for decades. What this study does is connect that anchor to the RGA quantification chain, and remind every user of one thing: **before attaching the anchor, decide where the head stands.**

For semiconductor processing, this is a directional step: **turning vacuum from an experience-based variable into a quantitative variable that can be designed, reproduced, and transferred.**

Note: This is the popular-science edition of the technical study of the same name. It presents principles, ideas, and significance only, and contains no experimental methods or data.

Conflict-of-interest statement: The author’ s affiliation, RealMeter Instruments (Shanghai), develops and markets calibrated leak standards and related products.