RESIDUAL GAS ANALYSIS

Why Qualitative Data Trends Matter More than Quantitative Values

Many users expect quantitative data from residual gas analyzers (RGAs), but the reality is that most in situ setups don't need (or benefit from) quantitative outputs. In situ RGAs provide real-time process monitoring in a manufacturing setting, and the qualitative data they deliver allow for more actionable, reliable insight into live monitoring and process diagnostics.

Data That Works *for* You, Not *Against* You

In process monitoring, data is power, but only when it's the right kind of data. If you've ever wondered why an in situ RGA outputs signals in amperes (amps) instead of more familiar units like Torr or parts per million (ppm), you're not alone. Many users think quantitative measurements will help them understand gas composition during processing, but in situ RGAs are actually best suited to provide qualitative data. That's not a limitation—it's a strength.

Quantitative vs. Qualitative

Quantitative data provides absolute values, for example, 1.2×10^{-6} Torr of nitrogen. It's the kind of measurement that can be compared across tools, labs, or industries. Qualitative data, by contrast, is relative: it tells you if a gas signal increased, decreased, appeared, or disappeared. In RGA terms, it looks like a spike at mass 18 or a gradual rise in ion current for mass 44.

Table 1. Converting qualitative data to quantitative data

REQUIREMENT	WHY IT'S A CHALLENGE
Calibration gas	Must match your gas mix exactly
Stable pressure	Not realistic during process changes
Fragmentation models	Vary by gas, hard to isolate
Stable temperature	Not realistic during temperature varying process

Users often prefer quantitative values in ppm or Torr because those units feel more concrete and familiar. However, getting to that level of measurement comes at a cost that is typically unjustified in dynamic process environments. To deliver absolute quantitative data, the system must be extensively calibrated for each target gas under very specific, stable conditions. These conditions must remain tightly controlled for any calibration to hold, which is rarely feasible in a live manufacturing setting.

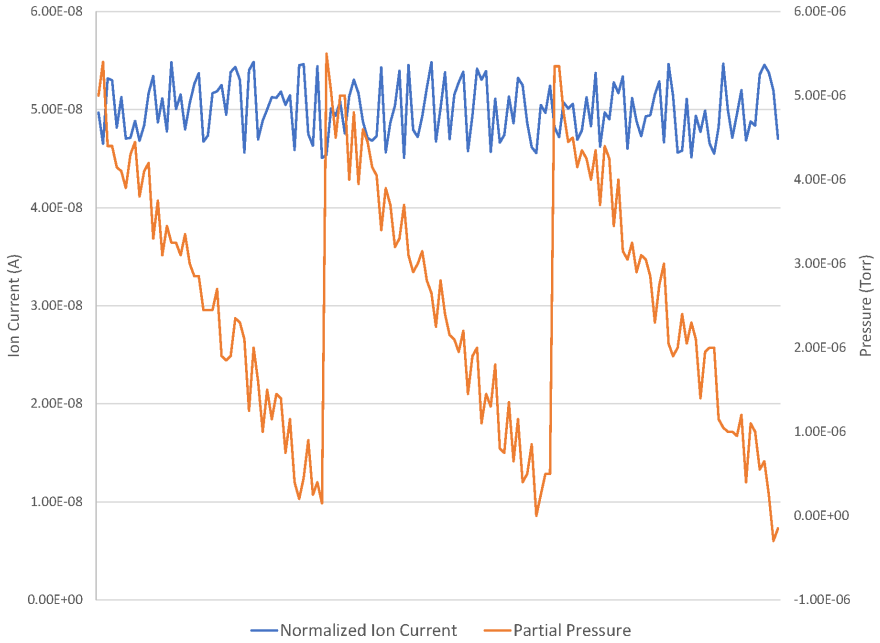

Figure 1. Comparison of the ion current normalized to total ion current vs. the partial pressure of the same m/z over time.

Understanding RGA Output in Amps

An RGA detects gas molecules by ionizing them and measuring the resulting signal as an ion current, reported in amps. The size of this current is generally proportional to the amount of that gas present. However, that proportionality is complicated by the fact that different gases ionize with different efficiencies, fragment into different mass peaks, and respond differently to the detector. Even ambient process changes like chamber pressure, temperature, and gas flow dynamics can influence the measurement. Table 1 lists a few requirements for absolute quantitative measurements and why they are a challenge to obtain.

To convert ion current to an absolute unit like Torr, you would need carefully prepared calibration gas mixtures of known composition. You would also need to ensure the pressure,

temperature, and flow conditions during measurement exactly match those during the calibration, which is rarely realistic in situ. On top of that, you must model and compensate for complex fragmentation behavior of overlapping species, and regularly repeat this process to account for drift over time. This introduces substantial overhead and uncertainty.

Figure 1 illustrates how absolute partial pressure signals can change over time and need frequent calibrations to correct for this change, all while the normalized ion current can maintain stability without the need for frequent calibration. The result is that absolute quantitative RGA use becomes limited in scope, is difficult to maintain, and is often misleading, which is all in contrast to the adaptability that in situ monitoring demands.

The Case for Qualitative Data

Despite lacking absolute units, qualitative RGA data is extremely effective for live monitoring and process diagnostics. A well-configured in situ RGA can reveal when a process is deviating from expected behavior, often in real time.

For example, if you establish a baseline spectrum during a stable etch step, any unexpected increase at mass 18 (water), mass 28 (nitrogen), or mass 44 (CO_2) may indicate a leak, contamination, or an upstream process issue. These changes are easily spotted in ion current readings without needing to translate them into pressure or concentration values.

Users can compare current trends to previous runs, flag deviations early, and act before defects occur. Rather than absolute values, it's the shape of the data over time—the rising, falling, or sudden appearance of a mass peak—that reveals process health. This makes qualitative data not only sufficient but often preferable for fast, in situ decision-making. This is what is referred to as fingerprints and fingerprint matching. Figure 2 illustrates specific peaks identified during different processes and their relative intensities. This table can be used as a baseline and be measured against during active processes to identify changes and trends in the process chemistries.

A Common Misunderstanding about RGA Output

It's completely reasonable to want numbers that correspond to units like ppm or Torr. These values feel objective and trustworthy. But in many real-world applications, those numbers can actually be misleading. Because quantitative readings rely on controlled conditions that shift constantly in live systems, their accuracy degrades quickly.

A value in Torr might look precise, but if it's based on assumptions that no longer hold, such as a changed ion source sensitivity or chamber pressure, that number becomes a liability, not a benefit. Meanwhile, normalized ion current trends can still show you exactly when something changes in your process, and that's what matters most.

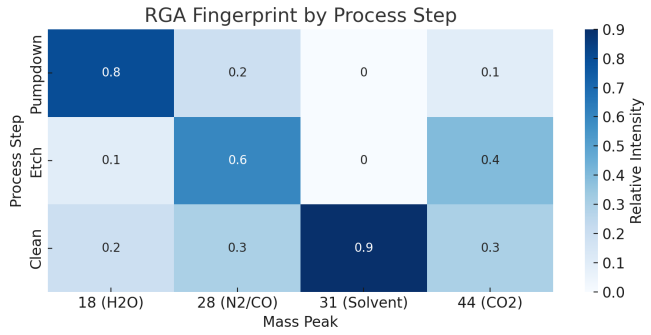

Figure 2. Normalized gas fingerprint based on amu and process step.

Best Practice: Build a Baseline, Monitor for Change

The most powerful use of in situ RGA data is to develop a process-specific baseline. Record a reference spectrum for each key process condition—such as pump down, etch, deposition, or clean—and compare future runs against these benchmarks. This allows users to quickly recognize when an unusual signal appears or when a known gas shows unexpected behavior.

For example, the sudden rise of water vapor (mass 18) during what should be a dry etch step might indicate a back-streaming event or a poor chamber purge. The presence of mass 28 during vacuum might point to a leak or outgassing issue. These detections don't require you to know how much gas is present, only that something is different.

Many users build "gas fingerprints" for each stable process condition, allowing them to track consistency over time. This approach improves yield, reduces downtime, and gives process owners more confidence in what their system is doing at every stage. This is the first building block for statistical process control (SPC) analysis with in situ RGAs.

Focus on Trends, Not Units

In situ RGAs are not intended to replace laboratory mass spectrometers or calibrated pressure gauges. Their strength lies in providing real-time, repeatable insight into how your system behaves, not in assigning precise numbers to every gas species.

By focusing on how signals change over time, and comparing against known baselines, you can get ahead of issues before they escalate. This qualitative approach is more robust, more adaptable, and better aligned with the demands of live process control and quality SPC.

The next time you're reading RGA data in amps, ask yourself not "What's the partial pressure value?" but rather, "How does this compare to my baseline?" The answer will almost always be more useful and more reliable.

More information → inficon.com

aiam27a1