



HOW ONLINE PROCESS ANALYSERS ARE CHANGING PETROLEUM OPERATIONS

As process industries move away from delayed laboratory feedback toward real-time, in-situ analysis, Gregory Shahnovsky examines how advanced monitoring technologies are becoming essential drivers of safety and operational efficiency in both the refining and hydrogen sectors.

Process industries have always depended on measurement. But the operational value of “knowing the process” has changed fundamentally over the last decade. Industry analysts increasingly view real-time measurement as a prerequisite for safe hydrogen deployment.

Refineries now handle wider feedstocks and tighter product specifications. Gas networks are repurposed for hydrogen blending and new duty cycles. Chemical plants operate at higher utilisation with far less tolerance for downtime.

At the same time, regulatory and safety expectations continue to rise. There is increasing requirements for continuous monitoring, emissions reporting and functional safety verification.

Historically, many plants were built around delayed quality feedback. Laboratory results confirmed what had already been produced. If deviations were found, the correction came too late to prevent losses.

In modern operations, this model is no longer viable. Measurement must arrive in time to shape the process itself, not merely document it.

This shift has forced a re-examination of analyser technology – particularly the relationship between the sensing element, the sample system and the software layer that converts raw signals into operational decisions.

The classical era: extractive analysers and the limits of sample systems

For decades, most process analysers were designed around an extractive architecture:

1. A representative sample is withdrawn from the process line
2. The sample is conditioned (pressure reduction, temperature stabilisation, filtration, phase separation, moisture removal)
3. The conditioned sample is transported to an analyser cabinet or shelter
4. Process samples discharged to sample recovery systems or atmospheric vent/drain, unless they do not adversely affect environmental quality
5. The analyser performs the measurement and the result is transmitted to the control system.

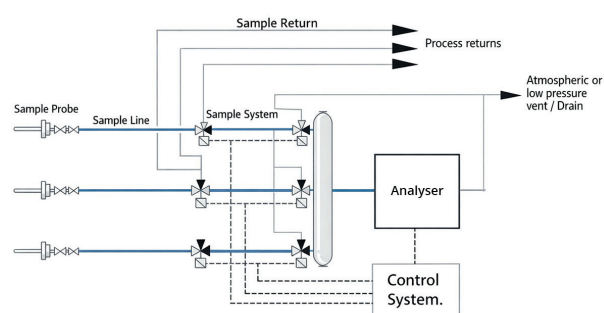


Figure 1: Extractive process analysers architecture

In this architecture, the sensing technology is only one part of the reliability chain.

In real plants, it is often not the sensor that fails first – it is the sample system.

Common failure mechanisms

Condensation and phase change – small temperature drops in sample lines can shift hydrocarbon dew points, forming liquids where the analyser expects gas or vapour, where liquid is expected. This distorts composition and damages components.

Adsorption and memory effects – polar species and trace contaminants can adhere to tubing, filters and regulators. This produces long recovery times and false stability, particularly problematic in blending or trace analysis.

Clogging and pressure instability – filters foul, regulators drift and flow controllers degrade. Even small instabilities can create large measurement errors, especially for low-concentration components.

Transport delays – long sample lines add seconds to minutes of lag. In fast-changing processes, this makes analyser data unsuitable for real control.

Safety and compliance complexity – venting, purging, hazardous-area classification and work permits introduce operational burdens and safety risks.

To address these issues, the industry responded with more elaborate sample handling including heated lines, fast loops, coalescing filters, permeation dryers, climate-controlled shelters. While these improvements increased reliability, they also made analyser systems bulky, expensive and maintenance-intensive.

Moving the measurement to the process

Over the last 15-20 years, a clear shift has occurred toward in-situ and in-line measurement architectures. The logic is straightforward:

- If most errors are introduced between the process and the analyser, reduce or eliminate that path
- If the process is hazardous, minimise the number of leak points and sample handling components
- If faster control is required, reduce dead volume and transport time.

This transition has been enabled by advances in:

- Optical sensing methods
- High-performance materials and coatings
- Embedded digital signal processing
- Field communications and diagnostics
- Multivariable data interpretation tools.

In-situ analysers now operate directly on high-pressure, high-temperature or corrosive streams, providing faster and more representative measurements.

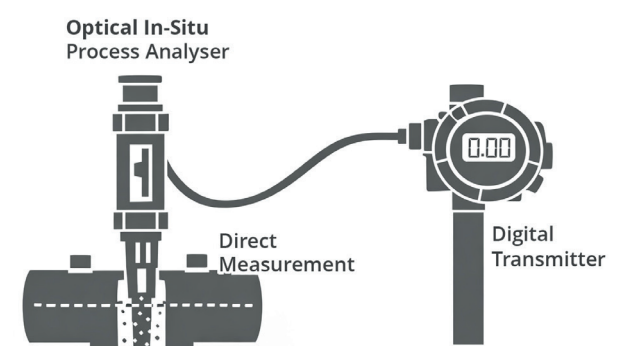


Figure 2: In-situ process analysers

Optical technologies:**why they changed the performance envelope**

Optical analysers are not new, but modern designs differ fundamentally from earlier “optical bench” systems.

Higher selectivity and stability – modern optical methods target specific spectral features that are less sensitive to cross-interference and drift than traditional electrochemical or wet-chemistry techniques.

Reduced consumables – many optical sensors avoid electrolytes, reagents or carrier gases, reducing operational cost and maintenance.

Suitability for harsh environments – with appropriate mechanical design and certification, optical sensors can be installed directly on high-pressure or hazardous process lines.

Built-in diagnostics – signal intensity, baseline stability, and optical path integrity can be monitored continuously, supporting predictive maintenance and early fault detection.

As energy systems transition and process complexity increases, real-time analysis is no longer a support function – it is a core element of plant operation

Why real-time measurement now matters more than ever

Whether processing crude oil, reforming hydrocarbons or producing hydrogen, industrial systems now operate across broader, more nonlinear conditions than in the past.

Hydrocarbon operations face variability from changing feedstocks, renewable integration, and tighter fuel specifications.

Hydrogen systems are exposed to membrane degradation, gas crossover, purity fluctuations, dynamic electrolyser loads and embrittlement risks.

In all of these cases, real-time analysers provide something no digital model can generate synthetically: verified physical evidence of what is actually happening inside the process stream.

Without this grounding, control strategies and optimisation models lose reliability.

In-situ analysers in refining and hydrogen service

Modern plants increasingly rely on analysers that measure directly within high-pressure or hazardous environments.

In refining, analysers support:

- Real-time crude characterisation
- Distillation and fractionation optimisation
- Fuel blending for gasoline, diesel and jet fuel
- Flare oxygen monitoring for safety and emissions compliance.

In hydrogen systems, analysers monitor:

- Oxygen in hydrogen streams (to prevent explosive mixtures and detect membrane ageing)
- Hydrogen purity (for fuel-cell grade specifications)
- Hydrogen concentration in natural gas blending (to maintain Wobbe index and pipeline integrity).

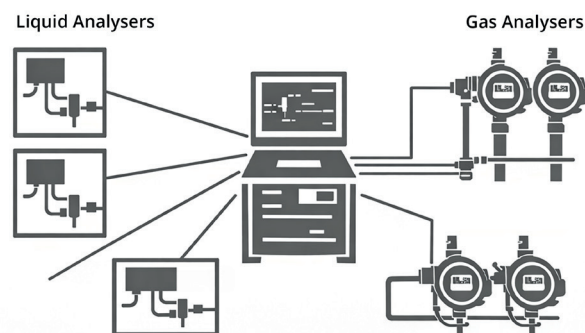


Figure 3: Analysers for high-pressure and hazardous environments

Technologies such as quenched fluorescence, tunable diode laser absorption, near-infrared spectroscopy and thermal conductivity measurement enable continuous monitoring with minimal maintenance.

From data to action: the role of advanced analytics

Collecting real-time data is only the first step.

The operational value emerges when measurements are used to guide decisions continuously.

Modern facilities increasingly combine analyser data with multivariable models that learn process behaviour, detect abnormal conditions and recommend optimal operating strategies.

These systems do not replace operators; they provide a quantitative framework that helps them act faster and with greater confidence.

In refining, this approach improves:

- Energy efficiency
- Throughput stability
- Blend quality consistency
- Cut-point accuracy.

In hydrogen operations, it supports:

- Early crossover detection
- Load-following optimisation
- Purity control during compression and storage
- Stable blending ratios in mixed gas networks.

Safety and efficiency: no longer competing goals

In both refinery and hydrogen service, safety and efficiency are now part of the same operational objective.

Continuous measurement combined with intelligent control enables:

- Early detection of unsafe mixtures
- Prevention of equipment degradation
- Reduced flare emissions
- Improved combustion stability
- Higher product consistency
- Lower energy consumption.

This integrated approach creates a resilient operating envelope even under variable conditions.

The measurement-driven facility

As energy systems transition and process complexity increases, real-time analysis is no longer a support function – it is a core element of plant operation.

The refinery, gas network and hydrogen facility of the future will be defined not only by equipment capacity, but by how effectively they transform measurement into timely, reliable decisions.

In this environment, the role of process analytics is evolving from passive monitoring to active participation in process control.

The industry’s challenge is not simply to measure more – but to measure better, faster and with greater operational relevance.

Gregory Shanovsky is a process control and optimisation engineer with more than 30 years of experience in industrial process analysis and optimisation. His work has focused on refinery, petrochemical, and energy-related applications, including real-time measurement, process safety and digital optimisation. He has authored numerous industry publications on process analysis, hydrogen safety and refinery optimisation. He has been with MODCON since 1990 and currently serves as President and CEO of the MODCON Group.

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