

# Integrated Design: Accuracy and Precision of Agilent ICP-OES Instruments

Agilent 5800 ICP-OES and Agilent 5900 ICP-OES



## Introduction

In modern elemental analysis, data quality and reliability is paramount. ICP-OES users depend on both instrumental design and software capabilities to achieve consistent, traceable, and reproducible quantitative results.

Agilent 5800 and 5900 ICP-OES instruments integrate innovations in advanced optical engineering, robust plasma control, and intelligent software. Together, these features provide exceptional analytical accuracy and precision across challenging sample matrices and wide dynamic ranges.

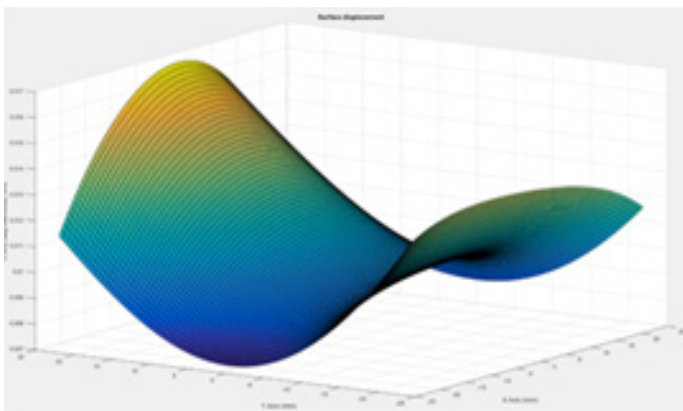
## Freeform optical design: Enhanced resolution and signal integrity

The 5800 and 5900 ICP-OES use the most innovatively designed freeform optics in the polychromator. The highly customized asymmetric and aspheric surface of the Agilent freeform collimating mirror (Figure 1) corrects for all types of optical aberrations across the entire wavelength range, including both the visible and ultraviolet wavelengths, simultaneously. The high degree freeform surface corrects spherical aberrations, coma, and astigmatism, which typically occur on wavelengths as they deviate from the center of the detector.<sup>1</sup>

### Impact on accuracy and precision

- Reduced aberrations produce sharper peaks and higher signal-to-background ratios, improving quantitative integration.
- Enhanced resolution (<7 pm at As 188.980 nm) ensures better discrimination of closely spaced spectral lines, improving selectivity and minimizing interference errors.
- Improved focus leads to superior peak symmetry, directly supporting repeatable measurement integration.

In contrast to systems that rely on conventional parabolic or toroidal optics that can produce broader peaks and elevated background in the UV region, the Agilent freeform mirror maintains narrow peak shapes and low background, improving trace-level precision.



**Figure 1.** Deviation of the freeform surface from a perfect spherical surface. The freeform surface has a unique shape that has been optimized to provide a sharper focus and higher light intensity on the detector, producing higher sensitivity.

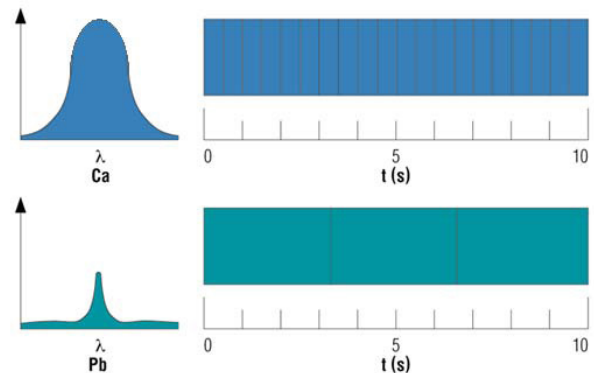
## True simultaneous echelle optics with Adaptive Integration Technology

The Agilent ICP-OES systems' echelle polychromator and proprietary VistaChip III charge-coupled device (CCD) detector capture the entire wavelength range simultaneously in a single integration. To prevent signal saturation and optimize the signal-to-noise ratio, Agilent Adaptive Integration Technology (AIT) automatically adjusts integration time per emission line (Figure 2), with no expertise required on the part of the user.<sup>2</sup>

### Impact on accuracy and precision

- True simultaneous data capture eliminates any time-based variability between element measurements.
- Real-time integration control maintains linear detector response across the full dynamic range.
- Internal standard and background correction occur simultaneously, improving data stability.
- Image Mapping Technology (I-MAP) maintains precise pixel-to-wavelength mapping for long-term optical consistency.

Unlike systems that capture wavelengths through sequential subregion scanning, the Agilent design acquires the entire spectral range in true simultaneous fashion, eliminating temporal drift and ensuring consistent signal integration.



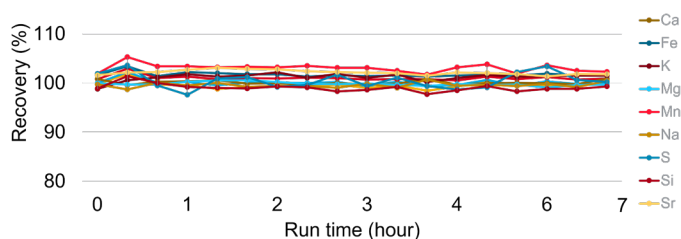
**Figure 2.** Using a user-defined total replicate read time, AIT averages many short readings for high-intensity signals and fewer, longer readings for low-intensity signals, simultaneously providing the optimum signal-to-noise ratio for all lines.

## Robust vertical torch and solid-state RF system

All Agilent ICP-OES instruments feature a vertical torch orientation and 27 MHz solid-state RF (SSRF) plasma generator. This configuration supports stable plasma conditions throughout the analysis of high dissolved solids (up to 30% NaCl) and volatile organic matrices (Figure 3).<sup>3</sup>

### Impact on accuracy and precision

- Vertical sample introduction minimizes salt buildup and signal drift over long sequences.
- Free-running RF design automatically compensates for plasma load changes, delivering a stable plasma for accurate and reproducible measurements over long periods.
- Automatic torch alignment ensures reproducible optical coupling and minimizes the day-to-day variance experienced in instruments which require manual torch alignment.



**Figure 3.** Long-term stability of the Agilent 5900 ICP-OES during the analysis of raw lithium brine over seven hours (TDS content over 31%).<sup>4</sup>

## Advanced Valve System (AVS) with controlled argon bubble segmentation

The Agilent Advanced Valve System (AVS) six or seven valve accessory dramatically increases instrument productivity, reduces sample load on the plasma, and allows for the introduction of controlled argon gas bubbles (rather than air) between sample and rinse solutions.<sup>5</sup>

### Impact on accuracy and precision

- Halving sample-to-sample time allows for sample batches to be run with an equivalent 50% reduction in time-based variability in sensitivity and wavelength position compared with non-AVS systems.
- Reduced exposure of the plasma interface to the sample matrix gives reduced signal variability and improved short- and long-term precision, as well as less frequent sample introduction system cleaning.

- Argon segmentation isolates each sample solution, eliminating dilution and carryover effects, maintaining plasma equilibrium between analyses, and reducing baseline noise.
- Uptake and rinsing of sample lines by the separate high-speed positive displacement pump allows for the primary peri-pump flow rates to be consistent. This flow stabilization ensures minimal fluctuations in plasma temperature, allowing reduced stabilization times and improved accuracy.

The use of argon bubble segmentation maintains plasma stability and improves short-term precision, avoiding the variability associated with air-segmented systems, as the results for the repeated measurement of a 5 ppm Mn solution demonstrate (Table 1).

**Table 1.** Analytical precision of 3 x 5 second replicate measurements of a 5 ppm Mn solution, using an Agilent ICP-OES with an integrated AVS 6.

	Analytical Precision (%RSD)
5 ppm Mn with Ar injection	0.5
5 ppm Mn with air injection	1.0

## Standard bracketing in Agilent ICP Expert Pro 7.8

Standard bracketing is a high-precision calibration technique for ICP-OES analysis, designed to deliver accurate quantification of target elements in sample materials. In industries where elemental composition defines both product quality and commercial value (such as precious metals refining, alloy verification, and advanced materials processing) measurement integrity is essential.

The standard bracketing capability introduced in Agilent ICP Expert Pro 7.8 allows for automated bracketing of calibration standards within analytical runs. This capability provides exceptional accuracy and precision for demanding applications, particularly within the precious metals industry.<sup>6</sup>

### Impact on accuracy and precision

- Standard bracketing enables highly accurate and precise results by measuring samples between low and high calibration standards, correcting for instrumental variations.
- Ideal for complex samples, such as precious metal alloys, where precise elemental composition determination is critical for quality assurance and regulatory compliance.

- High-precision analysis delivering better than 0.1% RSD, as demonstrated for precious metals such as Pt, Au, and Pd when analyzing samples according to ISO 11494 and 11495 (Table 2).<sup>7,8</sup>

ICP Expert provides built-in result summarization and support ISO-compliant reporting formats, allowing results to be expressed as fineness, karat, or concentration units.

**Table 2.** Results in fineness (‰) and precision of two sample duplicates using standard bracketing.

		Fineness (‰)	RSD (%)
<b>Au 267.594</b>	Aliquot 1	755.40	0.052
	Aliquot 2	756.59	0.071
<b>Pd 342.122</b>	Aliquot 1	997.21	0.055
	Aliquot 2	999.22	0.033
<b>Pt 224.552</b>	Aliquot 1	944.86	0.048
	Aliquot 2	941.36	0.044

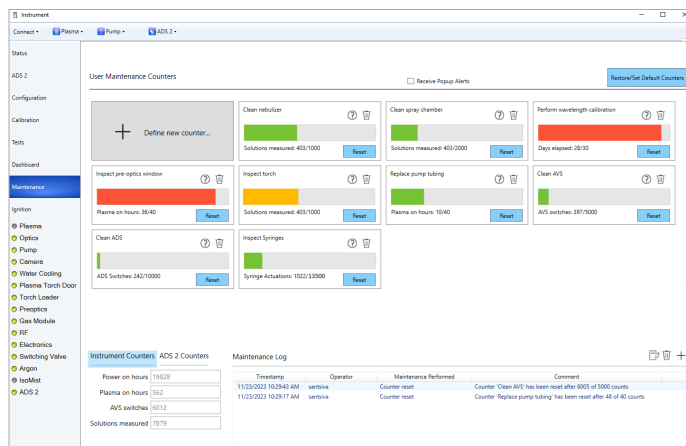
## ICP Expert software: Quality assurance and outlier detection

The ICP Expert software provides features to continuously monitor analytical precision and result consistency, flagging issues early. Early Maintenance Feedback (EMF) and integrated Instrument Performance Test capabilities allow users to ensure that their instruments are always operating at peak efficiency.<sup>9,10</sup>

### Impact on accuracy and precision

- Real-time flagging of inconsistent results (for example, %RSD, internal standard drift) enables early identification of these issues and prevents incorrect results from being reported.
- Automated performance validation confirms that the instrument meets requirements before analytical operation.
- EMF user alerts for routine instrument maintenance allow flagged tasks to be performed before they impact analytical accuracy (Figure 4).

By integrating EMF and automated performance verification, ICP Expert provides assurance of instrument readiness—an advantage over workflows that depend on manual checks or external monitoring.



**Figure 4.** Early maintenance feedback functionality with an integrated maintenance log helps to keep your instrument properly maintained, reducing unplanned downtime and ensuring that you continue to produce consistent, high-quality results.

## Internal standardization: Correcting matrix effects for accurate and precise results

An internal standard element is added at a constant concentration to all calibration standards, blanks, and samples. The signal from each analyte is expressed as a ratio to the internal standard signal. Because analyte and internal standard elements experience identical conditions in the sample introduction system, plasma, and optics, any short-term fluctuations or matrix-related effects are automatically corrected.

The ICP Expert software automatically applies internal standard correction during data processing, displaying recovery trends and flagging results that fall outside user-defined limits through Outlier Conditional Formatting.

### Impact on accuracy and precision

- Differences in viscosity, surface tension, and nebulization efficiency between samples can alter aerosol transport. Internal standardization normalizes analyte signals to correct for these variations, ensuring stable response across samples.
- Plasma load or temperature changes can transiently influence emission intensity. An appropriately chosen internal standard with similar excitation characteristics to the analyte element compensates for such variations, maintaining analytical stability.

- Gradual changes in torch condition, nebulizer performance, or optical sensitivity can introduce signal variability over time. Internal standard normalization automatically adjusts for these changes, preserving calibration accuracy over extended runs.

Without internal standardization, matrix-dependent variations can appear as signal variability or poor precision; Agilent's automated correction normalizes these effects in real time.

## Conclusion

This note outlined a suite of integrated design and software features, including freeform optics, true simultaneous echelle optics with Adaptive Integration Technology, a robust vertical torch and solid-state RF system, an Advanced Valve System with controlled argon bubble segmentation, as well as standard bracketing, quality assurance and outlier detection capabilities, and internal standardization. Combined, these innovations ensure that the Agilent 5800 and 5900 ICP-OES instruments, powered by Agilent ICP Expert Pro 7.8 software, deliver the precision, accuracy, and reliability required by elemental analysis laboratories across many sectors.

## References

1. Innovative Freeform Optical Design Improves ICP-OES Speed and Analytical Performance, Agilent publication, [5994-5891EN](#)
2. Superior ICP-OES optical design for unmatched speed and performance, Agilent publication, [5991-4838EN](#)
3. Benefits of a vertically oriented torch - fast, accurate results, even for your toughest samples, Agilent publication, [5991-4854EN](#)
4. Garcia-Gonzalez, A. ICP-OES Quality Control of Elements in Brines Produced by Direct Lithium Extraction (DLE), Agilent publication, [5994-8041EN](#)
5. Reduce Costs and Boost Productivity with the Advanced Valve System (AVS) 6 or 7 Port Switching Valve System, Agilent publication, [5991-6863EN](#)
6. High Precision Analysis of Major Components in Precious Metals by ICP-OES, Agilent publication, [5994-8849EN](#)
7. ISO 11494:2019 Jewellery and precious metals – Determination of platinum in platinum alloys – ICP-OES method using an internal standard element, <https://www.iso.org/standard/75285.html>
8. ISO 11495:2019 Jewellery and precious metals – Determination of palladium in palladium alloys – ICP-OES method using an internal standard element, <https://www.iso.org/standard/75284.html>
9. Agilent ICP Expert Software, Agilent publication, [5994-1517EN](#)
10. Smart Health Checks for ICP-OES, Agilent publication, [5994-4381EN](#)

[www.agilent.com/lifesciences/icpoes](http://www.agilent.com/lifesciences/icpoes)

DE-0011160

This information is subject to change without notice.

© Agilent Technologies, Inc. 2025  
Published in the USA, November 27, 2025  
5994-8853EN