

FROM INNOVATION TO INSIGHT: Introducing Avio 3000, the Third Generation of ICP-OES Technology

Three re-engineered subsystems aim to reduce laboratory operating costs and operator dependence for inductively coupled plasma optical emission spectroscopy (ICP-OES) analysis.

Introduction

Laboratories performing trace elemental analysis are expected to meet multiple demands at once. Sample volumes continue to grow while experienced operator headcounts stay the same, making every rerun analysis a productivity loss. Simultaneously, operational costs compound each year due to rising electricity rates, escalating argon costs, and the maintenance of auxiliary systems like liquid chillers and heating, ventilation, and air conditioning (HVAC) infrastructure. Complex sample matrices further challenge analyses as regulated environments demand maximum uptime to complete scheduled batches without mid-batch failures. This expectation is compounded by tightening detection-limit requirements from the EPA, ISO, and other regulatory bodies. Laboratories require streamlined, robust instruments that simplify operations, reduce operator dependence, and deliver defensible, high-quality data. This paper highlights how the Avio® 3000, an inductively coupled plasma optical emission spectrometer (ICP-OES), can address these challenges to improve laboratory productivity.

Features of the Avio 3000 ICP-OES

Rather than a refresh, the Avio 3000 ICP-OES is a ground-up redesign, meant to resolve laboratory pressures at the source instead of relying on external, bolt-on accessories. Three core subsystems—the plasma generator, optical spectrometer, and detector—were re-engineered from independent research



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programs and are protected by individual patents. Only four components carry over from the predecessor Avio 550 platform: the pump, nebulizer, spray chamber, and a secure mounting clip.

These three subsystems translate into changes that are both visible to the user and embedded in the instrument's underlying architecture. A well-lit sample introduction area, for example, makes it easier to connect tubing and install the spray chamber, nebulizer, and torch. The redesigned radiofrequency (RF) generator is focused on simplifying operation and improving plasma robustness. It incorporates HeliPlate™ plasma technology, which builds on PerkinElmer's proven Flat Plate™ oscillator design that consumes up to 50% less argon than traditional helical coils. The non-planar, bent geometry of these plates is engineered to optimize electromagnetic coupling with the plasma discharge, while electronics operate well below the generator's maximum capacity to provide additional operating headroom at full power.

The air-cooled design also eliminates the need for a chiller, avoiding the maintenance and corrosion risks associated with traditional copper coils. These design choices translate into measurable stability. Testing demonstrates less than one percent plasma power variation over 24 hours of continuous temperature and chemical cycling, even during alternating exposures to acid, saltwater, water, and air without liquid introduction. Furthermore, the system achieves a 99% ignition success rate and has been verified across multiple generators for more than 2000 hours.

Fluidic and Gas Flow Innovations

Advancements to RF and plasma-management improve not only system stability and robustness

but also the efficiency of the fluidic and gas flows that support plasma operation. The HeliPlate design offers up to a 50% reduction in argon flow compared to older helical-coil instruments. Laboratories moving from older helical-coil systems running high gas flows may see the largest reductions, while those already using Flat Plate technology will see smaller, yet notable, changes. Excluding labor, argon is typically among the highest recurring consumable expenditure for an ICP laboratory. By lowering the argon flow rate, laboratories will see a direct cost savings. In tandem, the instrument uses a refined PlasmaShear™ system to manage the cool plasma tail plume just above the torch. This system opens a cleaner axial view with a longer path length into the plasma, sending more light to the spectrometer and improving sensitivity. Unlike alternative systems that rely on expensive argon or nitrogen gas flows, PlasmaShear employs a high-velocity jet of compressed air to mechanically cut off the plasma tail. The system also eliminates cones or orifices that can foul over time, particularly with high TDS (total dissolved solids) and reduces self-absorption to extend the working range. Operating independently, HeliPlate reduces plasma argon flow, while PlasmaShear avoids argon for plume control.

A Detector Built for Speed

Complementing the changes to plasma generation and gas management is a subsystem meant to capture more light within spectral analysis; it is a full-frame, back-side illuminated (BSI) complementary metal-oxide-semiconductor (CMOS) detector. Backside illumination removes the wiring layer from the light path, enabling direct detection of ultraviolet (UV) photons. Quantum efficiency peaks near 90% at ~193 nm, close to the

wavelengths of the most challenging elements. A Peltier cooling system holds the sensor at a stable -20 °C with negligible dark current, and readout noise falls below that of a typical CCD (charge-coupled device). Because the sensor is a single full frame with no subarrays, more spectral lines are available with no time penalty.

The proprietary pixel architecture of the BSI-CMOS represents a major leap in sample throughput. Rather than applying a single global exposure time, each individual pixel is read at its own ideal exposure time. The Avio 3000 can support up to 250 unique integration times within a single analytical acquisition with the shortest integration time being four microseconds. This pixel-specific control allows operators to acquire more replicates within a given read window while reducing relative standard deviations (RSDs) and improving precision. Compared with the Avio 550 Max system, throughput improves by about 40%.

Optics Tuned for Low UV

The detector's ability to rapidly capture spectral information is supported by the optical system, particularly for challenging low-UV wavelengths. It uses a free-form imager with a backside prism reflection technique and only one moving component, so fewer parts mean more light and less drift. Every reflective component within the spectrometer is coated with a proprietary UV-reflective layer, boosting sensitivity at wavelengths below 220 nm across an operating range of 167 nm to 900 nm. A high-resolution mode delivers roughly 6 pm resolution near 200 nm and about 20 pm at 550 nm, allowing users to separate close emission lines from analytes of interest. The entire assembly is thermally stabilized and internally calibrated, keeping wavelength drift, due to temperature, minimal.

Included with these optical improvements is a dedicated UV Boost mode—able to enhance performance at wavelengths below 243 nm—that further increases light throughput when additional sensitivity is needed. UV Boost mode expands the entrance slit vertically only, admitting more light while leaving resolution and purge flow unchanged. It is wavelength-selective, works in both normal and high-resolution modes, and recovers the sensitivity a high-resolution slit would otherwise cost. Regulated and difficult elements benefit most from the enhanced wavelength detection such as arsenic, selenium, thallium, antimony, lead, phosphorus, sulfur, and mercury. In comparison of a normal slit versus UV Boost on the same instrument, detection limits were roughly halved, with a signal-to-background improvement of about fivefold across the tested range.

To demonstrate performance, wastewater analysis under EPA Method 200.7 served as a stress test across 33 elements. High-resolution mode resolved an inter-element correction between chromium and arsenic, and UV Boost recovered the sensitivity that the high-resolution slit would otherwise reduce. The run processed 178 samples in eight hours at roughly a 62-second sample-to-sample pace before quality control. Signal drift stayed below 10% in 15% sodium chloride without internal standard correction; recovery of the reference standard held between about 80% and 110% across three consecutive runs. Most elements showed sub-1% RSDs.

When integrated, the three subsystems form a simultaneous, full-spectrum spectrometer. Every wavelength from 167 nm to 900 nm is available in a single acquisition, with no scanning or moving grating switches. The vertical dual-view plasma

can be read radially, axially, or both within one method, combining the trace-level sensitivity of the axial view with the wide working range of the radial view. An optional Universal Data Acquisition (UDA) mode can store the full spectrum for every run, allowing data to be extracted and reviewed later without reanalyzing the sample: useful for troubleshooting, method development and validation, as well as identifying unknown samples.

Cost of Ownership

With analytical and performance advantages established, it is important to examine the impact of the instrument's design on day-to-day operating costs. By eliminating the need for a liquid chiller, laboratory costs decrease as chillers consume substantial electricity all while requiring air conditioning systems to counter the significant heat added into the workspace. To quantify the economic impact, a financial model was constructed based on a single daily shift of 10 hours, operating five days per week. The model used a commercial electricity rate of 16 ¢/kWh, a standard HVAC coefficient of performance of three, and a 25% instrument heat load during the remaining inactive hours of the day. Under these parameters, the direct electricity consumed by a traditional chiller and the associated air

conditioning costs required to cool the room estimate \$3900 per year. Factoring in ~ \$2400 per year in excess argon reduction, and ~ \$500 per year in avoided chiller and coil maintenance, a laboratory can save ~ \$7000 in annual savings. That adds up to ~ \$49,000 over a seven-year instrument life, with a net present value near \$35,000.

Conclusion

For laboratories facing rising sample volumes, complex matrices, tighter detection requirements, and pressure on operating costs, ICP-OES technology must deliver more than incremental analytical improvements. By redesigning the plasma, optics, and detector together, the next-generation Avio 3000 addresses these challenges at the instrument level. The spectrometer is able to increase throughput and data quality while reducing consumables, infrastructure, and maintenance demands. By combining analytical performance with lower resource consumption and reduced infrastructure requirements, the Avio 3000 demonstrates how productivity and analytical confidence can complement one another rather than compete against each other. As laboratory demands continue to evolve, the three subsystems of the Avio 3000, alongside resilience, will define what laboratories expect from ICP-OES technology.

Watch the full on-demand webcast:
**Introducing the Avio 3000: The Third
Generation of ICP-OES Innovation**

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