

Avio 3000 ICP-OES Comprehensive Specifications

SPECIFICATIONS

ICP-Optical Emission Spectroscopy



PerkinElmer, a global leader in ICP-OES technology for more than five decades, has consistently advanced the field by delivering exceptional analytical performance for laboratories conducting trace elemental analysis. Its latest innovation, a third generation ICP-OES system—the Avio® 3000—extends this legacy. The Avio 3000 redefines true simultaneous ICP-OES by combining high analytical speed with accurate, defensible results every day, all while keeping operating costs under control.

This next-generation system is built around three completely newly designed core subsystems: the plasma, the optical system, and the detector.

The Avio 3000 features the industry's most robust plasma, enabled by the patented HeliPlate™ design, and best-in-class detection limits driven by its third-generation detector with backside illuminated (BSI) CMOS sensor and UV Boost mode which enhances signal-to-background ratios for UV lines < 243 nm—all without requiring a chiller. The fully air-cooled system eliminates the noise, heat, and energy consumption associated with traditional chillers.

This combination of innovative, unique capabilities has all been engineered to deliver best-in-class performance without the overhead, which you will learn about in this document.

KEY BENEFITS:

- Best-in-class detection limits
- Unmatched matrix tolerance
- Long-term stability
- High throughput with low maintenance
- Sustainability and low cost of operation
- Ease of use

No Chiller

Reduces noise, maintenance, heat, cost, and power consumption

PlasmaShear Technology

Eliminates the need for cones and additional argon

Status LEDs

Provide real-time instrument status (visible from anywhere in the lab)

Optimized Torch Design

Simplified operation, easy removal and maintenance

Patented Optical Design

Increased light throughput with reduced background from 167-900 nm

Patented BSI-CMOS Detector

Enables high-speed analyses with improved precision due to simultaneous readings for up to 250 different integration times (down to 4 μ s)

PlasmaCam

Enables real-time plasma viewing for method development

Illuminated Sample Introduction Area

Enhances visibility of spray chamber and nebulizer

Toolless Window & Filter Removal

Simplifies and speeds up maintenance

Open-Access Sample Introduction Area

Improved access to sample introduction components

Patented RF Generator with HeliPlate Plasma Technology

Robust plasma handles high dissolved solids and volatile solvents without a chilled spray chamber, at much lower argon flows



Overview: The Avio 3000 ICP-OES

- Outstanding signal-to-background ratio
- Excellent stability
- Unmatched matrix tolerance
- Multiple simultaneous integrations
- High throughput
- Lowest maintenance
- Lowest cost of operation
- Ease of use

Outstanding Signal-to-Background Ratio

Next-Generation Detector with Full-Frame BSI-CMOS Sensor:

At the heart of the Avio 3000 patented detector is an innovative, fully custom full-frame backside illuminated (BSI) CMOS sensor. The detector measures 28x28 mm and provides individual pixel readout with 3.5 megapixels. This detector was designed specifically for ICP-OES to deliver a high quantum efficiency (i.e., more electrons produced from the same number of photons). The quantum efficiency has been optimized for the low UV region of the spectrum (90% at 193 nm) to improve signal-to-background ratios for elements which are weak emitters and generally difficult to analyze by ICP-OES, such as arsenic, lead, antimony, phosphorus, selenium, sulfur, tin, and thallium. The high quantum efficiency, combined with the air-cooled technology, provides low dark current with the detector cooled to -20 °C, improving the signal-to-background ratios, allowing lower concentrations to be measured accurately.

This is achieved without the use of a chiller: the use of a CMOS sensor allows the detector to be cooled with only a fan, eliminating the expense of heat, noise, and maintenance associated with a chiller. The combination of these improvements provides lower relative standard deviations (RSDs) with faster analyses.

Polychromator: The Avio 3000 utilizes a patented high-energy echelle-based polychromator that delivers 6 μm of resolution at 200 nm and 20 μm of resolution at 550 nm. This is accomplished using a freeform optic which is combined with a prism. The polychromator is paired with a single patented full-frame backside-illuminated CMOS sensor to simultaneously cover the spectral range from 167-900 nm. All optical components are rigidly mounted to a monolithic optical bench within the purged and thermostatic-controlled optical enclosure to ensure optimal stability over the ambient operating range of the instrument.

The optical bench is purged with nitrogen to keep the system free of moisture and air to ensure the best operating performance. Low flow is 1 L/min and high flow is 5 L/min. Nitrogen is also used for axial window purge, simultaneously keeping the axial window free from contamination and increasing the axial UV sensitivities. Axial window purge is 1L/min (low purge) and 2 L/min (high purge). Argon (1.7 L/min or 6.0 L/min) is an acceptable substitute for nitrogen. The axial window purge is only flowing when the plasma is on. In standby, there is no axial purge flowing.

High Resolution: The unique optical system can be operated in normal or high-resolution modes. Normal resolution is used for many analyses due to its higher sensitivity, while high-resolution mode produces narrower peaks, as in Figure 1 where the thallium (Tl) doublet peaks are baseline resolved.

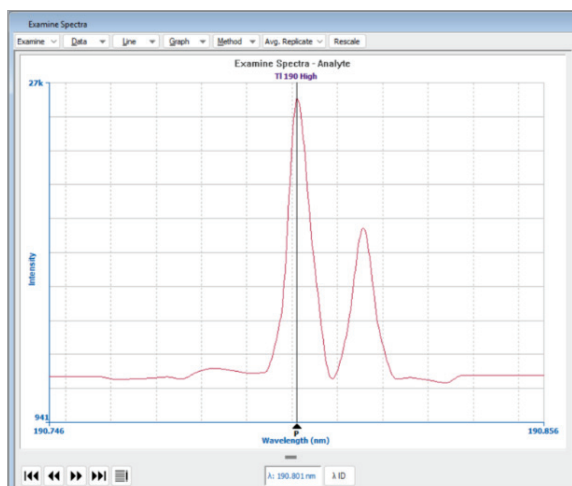


Figure 1. Spectrum of 0.01 ppm thallium (Tl) showing baseline resolution between the Tl doublet peaks.

Wavelength Calibration: With tens of thousands of available analytical wavelengths, a robust and accurate algorithm maps wavelength to image location on the large format sensor.

Wavelength calibration uses machine learning concepts to individually calibrate each instrument with sub-pixel accuracy. The astonishing accuracy guarantees that every selected wavelength of interest is not only correct but optimized for best performance.

UV Boost: UV Boost mode increases sensitivity for wavelengths less than 243 nm by expanding the slit in the vertical direction, allowing additional light to reach the detector. Because the slit expands only in the vertical direction, resolution is not compromised – instead, sensitivity is enhanced, as shown in Figure 2. The higher signal-to-noise ratio allows high-resolution operation to become standard practice, supporting effective interference reduction and minimizing the need for correction algorithms. The optimized design ensures superior detection limits across all sample matrices. Due to the increase in sensitivity using UV Boost, high resolution mode can now be used in the same method with virtually no time penalty to help with interference reduction or to reduce the signal.

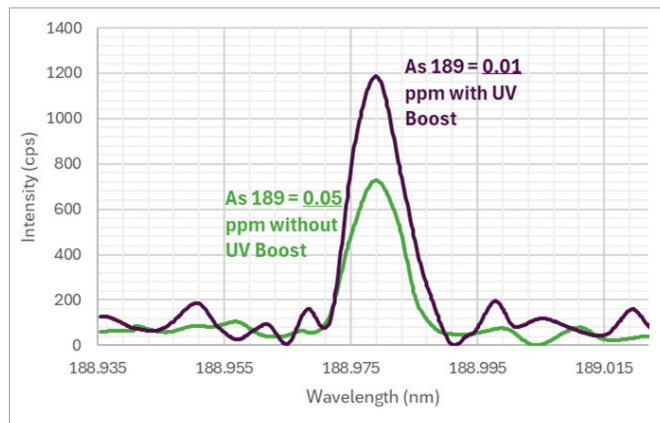


Figure 2. A more than 5x improvement with UV Boost. Spectra at As 188 comparing a 0.01 ppm As standard acquired with UV Boost (black) with a 0.05 ppm As standard acquired without UV Boost (green).

Optical Coatings: Each reflective optic within the Avio 3000 ICP-OES utilizes a reflective coating optimized for 193 nm, which increases light throughput, particularly throughout the UV region. Likewise, each transmissive optic utilizes an optimized anti-reflective coating designed to decrease stray light throughout the entire system. Each optic contributes to superior detection limits (Table 1) for all sample matrices.

Table 1. Low UV Axial Detection Limits on the Avio 3000 ICP-OES.

Detection Limits (ppt)	Non-UV Boost	UV Boost
P 177.494	980	490
S 180.669	1050	550
As 188.979	670	400
Tl 190.801	690	330
Se 196.026	1500	610
Pb 220.353	740	260

Excellent Stability and Unmatched Matrix Tolerance

RF Generator: The Avio 3000 ICP-OES instrument features a patented 40-MHz, free-running solid-state RF generator, adjustable from 700 to 1500 watts, in 1-watt increments. The new oscillator architecture utilizes laterally diffused metal oxide semiconductor (LDMOS) transistors for increased reliability, plasma robustness and power efficiency (80%) over traditional designs. True power control maintains the plasma power at the set point, ± 1 watt, even when changing sample matrices. The compact RF supply meets all FCC certification requirements for RF emission (Part 18 of FCC rules and regulations).

Plasma Source: The patented HeliPlate plasma technology (Figure 3) is maintenance-free and made of high-quality aluminum that runs without the use of a chiller or recirculator, reducing cost, maintenance, and noise while occupying less lab space. HeliPlate technology achieves greater plasma robustness and stability because of its unique design: two aluminum plates with altered geometry, which produce a uniquely shaped plasma that is robust and matrix tolerant, as shown in Figure 4 for an 8-hour analysis of 15% NaCl. The torch box was designed to minimize turbulence and stabilize the plasma while also removing exhaust fumes and contaminants, for plasma stability.

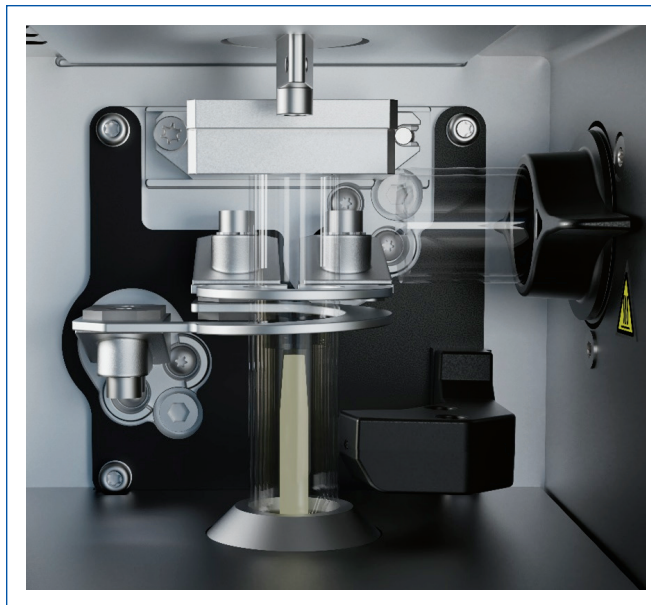


Figure 3. HeliPlate and PlasmaShear technologies provide low maintenance and low cost of ownership.

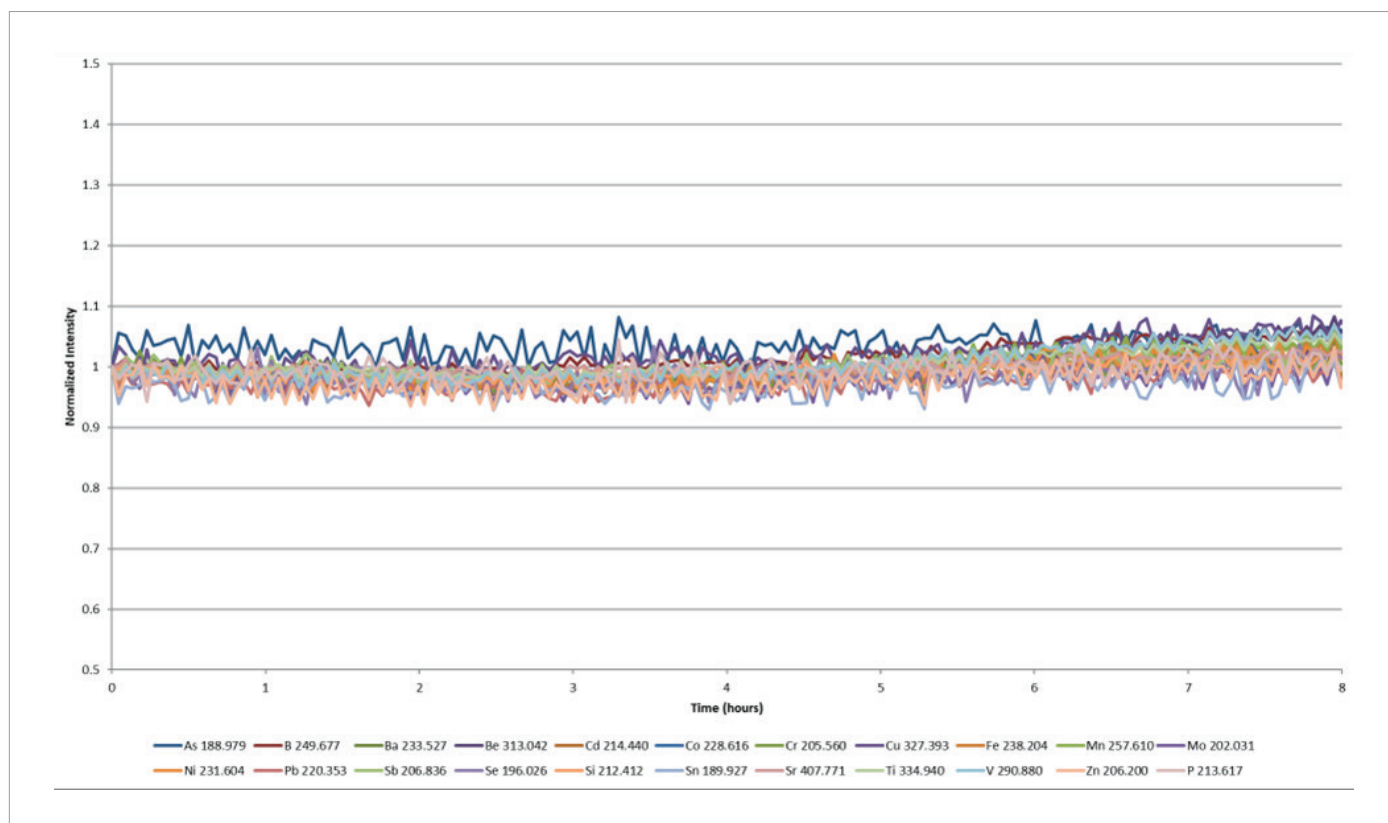


Figure 4. 8-hour stability of 15% NaCl.

Automatic Drift Correction: For labs suffering from poor lab environmental stability, an automatic drift correction algorithm was developed to keep the peaks stable throughout your analysis. The correction is only applied when a room-temperature change is detected, not done in a regular cadence, which reduces impact on analysis time and prevents over-correction. While the spectrometer is very resistant to room-temperature changes by design, drift correction ensures your lab environment will never affect your analysis.

Vertical Dual View Plasma: The system incorporates a vertically oriented plasma with complete dual-viewing optics under computer and software control. Any wavelength can be used in the radial, axial, or mixed viewing modes in a single method, providing maximum flexibility for the most difficult samples. With the dual view capabilities of the Avio 3000 system, viewing of the plasma is accomplished by computer control of a single mirror located in the optical path, which allows for selection of axial or radial view plus scanning of the radial viewing height. This simplified design with fewer moving pieces delivers robust, reliable performance.

Multiple Simultaneous Integrations

One of the unique features of the CMOS design is its measurement speed: the integration time can be as fast as 4 microseconds for each region of interest (ROI) for extremely high concentration samples. Each ROI corresponds to an analyte and is read independently at its optimum integration time, as determined by a pre-shot. Proprietary pixel structure with per-pixel readout control allows for independent exposure. Because the ROIs are independent of each other, they can be read simultaneously. The combination of simultaneous readings at the optimum integration time per analyte translates into the ability to measure high concentration signals without saturations and higher precision (i.e., lower relative standard deviations, RSDs), as displayed in Table 2, as well as low RSDs at short read times (Figure 5).

Table 2. Multiple Simultaneous Integration Times from 4 μ s to 1 s.

Analyte	Concentration (ppm)	Integration Time (μ s)	Intensity (cps)	% RSD (3 Replicates)
Na 589.592	1000	4	5,350,341,875	0.4
Mg 280.271	1000	4	4,448,428,960	0.6
Ca 396.847	1000	4	13,259,130,652	0.4
Sr 407.771	0.1	65,240	3,271,346	0.8
Ti 334.940	0.1	317,240	390,528	0.5
Al 396.153	0.1	381,192	107,731	0.4
Mn 257.610	0.1	499,968	290,166	0.6
Ba 233.527	0.1	999,992	73,881	0.1
Fe 238.204	0.1	999,992	81,782	0.3
Zn 206.200	0.1	999,992	33,262	0.2

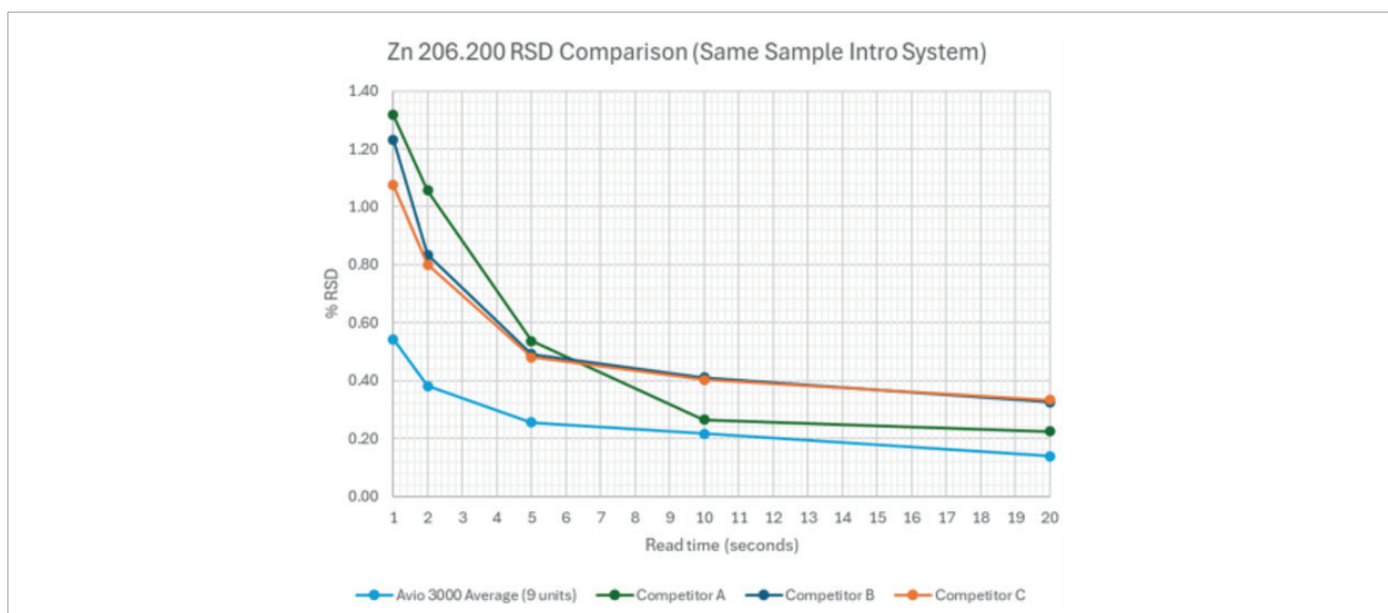


Figure 5. Typical %RSD performance from the Avio 3000 ICP-OES, providing < 1% on short read times.

Lowest Maintenance

Shear Gas: PlasmaShear™ is a compressed-air shear gas that is used to remove the plasma plume and to keep the heat away from the optics (Figure 6). This provides a more cost-effective approach to removing the cooler plasma zone, otherwise known as the plasma tail. Removal of the plasma tail from the optical path minimizes interferences and extends the dynamic range. Also, real-time elimination of non-vaporized complex sample matrices and carryover contamination prevent cone deposition with elemental particle deposits that would otherwise fall into the plasma and corrode the optics, resulting in improved signal stability and robustness. The PlasmaShear flow is 23 L/min (1 cubic foot/min) at a pressure of 260 – 290 kPa (38 – 42 psig). While cylinders of compressed air can be used, an air compressor is more practical.

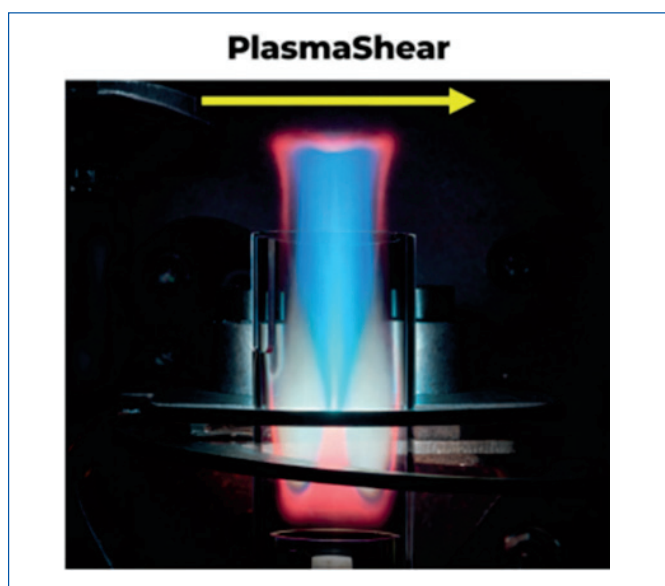


Figure 6. Photo of plasma aspirating 1% yttrium showing how PlasmaShear cuts off the tail of the plasma.

Torch and Injector Holder: A three-piece vertical torch, injector and holder design was engineered for ease of use, eliminating the need for torch alignment in both axial and radial plasma views. A one-piece quartz torch for plasma and auxiliary gas flow is supplied. The standard configuration includes a 2.0-mm i.d. alumina injector for full corrosion resistance to all acids, including hydrofluoric and aqua regia. A variety of other injectors are available. The externally mounted spray chamber is integrated into an easily removable sample-introduction cassette. No tools are required for torch or sample-introduction cassette removal. The simplified design requires no torch alignment – perfect positioning every time.

No Chiller: The inherent reliability of the system increases with no chiller. There are no water lines to leak or coolant to change. With reduced maintenance, this enables greater uptime in your lab.

Low-Maintenance Customer-Replaceable Air Filters: Toolless filter changes.

Low Cost of Operation and Sustainability

HeliPlate Technology: Two aluminum plates with altered geometry produce a uniquely shaped plasma that lowers argon consumption compared to traditional plasmas, with a typical plasma argon flow of 10 L/min, approximately half the consumption of helical load-coil systems. With argon being the highest-cost consumable in the lab, running at ~50% less argon can save on average \$4,000 per year per instrument, which equals \$40,000 over a 10-year lifetime of the instrument.

Chiller-Free System: Provides electricity, heat, and noise savings for the laboratory. Typical chillers will transfer approximately 3 KW of heat per 8-hour workday into the room. With an estimated cost of \$0.16 kW/ hour, this is \$1000 of electricity needed to remove the chiller heat from the room. These savings, along with the electricity savings of not having to power a chiller, approximately \$2000 per year, provide a total electricity savings of \$3000 per year for each instrument.

The combination of low maintenance and low cost of operation provides the laboratory with more uptime for sample analysis.

Ease of Use

The Avio ICP-OES series has always strived to deliver a streamlined user experience, providing a quick and smooth hands-on experience. Syngistix™ for ICP software is designed to mirror the actual user workflow with an icon-based, left-to-right navigation pane that walks users through day-to-day operation from startup, optimization, method development, and sample analysis to data review and reporting.

Automatic Method Wavelength Alignment: Optimizes peak position and reduces day-to-day variation in instrument performance. The routine can be completed manually when a method is first developed or automatically during your daily concentration calibration without adding any analysis time. This algorithm guarantees that your analysis starts perfectly with the system optimized, will increase confidence in analytical results and reduce the need for re-runs due to failed QCs. This capability, combined with drift correction, creates one of the most stable analytical instruments available on the market.

QuickStart: Provides a simple way for high-production labs to quickly and easily start analyses. From the Express Analysis window, simply select the method, sample list, location to save the data, and then press the Analysis button. That's it. No optimizations required, no additional windows to navigate – everything is done in a single window.

SmartQuant: Offers a customizable way to monitor all the elements capable of being measured by ICP-OES, presenting the results in a visual display which is quick and simple to understand and navigate. It can be customized to provide quantitative or semi-quantitative results for as few or as many elements as desired, with the capability of monitoring multiple wavelengths per element.

Automated Analysis: Delivers flexibility with the ability to automatically run multiple methods consecutively with a user-defined delay between methods. Furthermore, each method can be assigned to specific samples. Users can choose to run partial or complete sample lists, as well as insert priority samples. When an analysis is complete, data can be exported automatically, and the plasma turns off. To minimize the need for users to adjust peak positions after an analysis, both Automatic Wavelength Offset Correction and Automatic Method Align can be enabled. Automatic Wavelength Offset Correction adjusts for peak drift associated with changes in lab temperature, while Automatic Method Align automatically performs a wavelength calibration for the analytes in the active method. Plasma ignition is computer-controlled and totally automated. The software allows the plasma to be ignited automatically at a user-determined time and turned off automatically after an analysis.

Smart Diagnostics: In addition to the safety interlocks, there are numerous internal diagnostics that continuously monitor instrument health; for example, the input line voltage, current and frequency, the input gas pressures, the ambient temperature, pressure and humidity.

For user safety and system protection, the system constantly monitors exhaust flow, shear gas pressure, argon pressures, sample-compartment-door closure, torch installation, plasma stability and displays the interlock status on the computer screen as graphic symbols. If an interlock is interrupted, the plasma will immediately and safely extinguish.

A water-recirculating cooling system is NOT required due to the instrument's patented oscillator design.

Specifications Summary Tables

Standard Configuration		
	Component	Standard Configuration
	Nebulizer	The Avio 3000 ICP-OES can be ordered with a cross-flow or glass concentric nebulizer. The cross-flow design with GemTips™ is HF and corrosion-resistant (sapphire/ruby tips in a PEEK body). The system can routinely handle 50% (v/v) solutions of HCl, HNO ₃ , H ₂ SO ₄ , H ₃ PO ₄ , 20% (v/v) HF and 30% (w/v) NaOH.
	Spray Chamber	Instruments can be ordered with a Ryton® HF-resistant Scott-type or a glass cyclonic spray chamber.
	Torch	Quartz
	Injector	Alumina (2 mm i.d.)
	Peristaltic Pump	The integrated four-channel, 12-roller, computer-controlled pump has variable speeds from 0.2 to 7 mL/min in 0.1 mL/min increments, using 0.76 mm (0.030 in). Pump features include FastPump™ and SmartRinse™
	Customer Changeable Filters	Three (3) easily changeable filters. No tools required.
Plasma Ion Source		
	RF Generator	Patented air-cooled (chiller-free)
		40 MHz free-running solid-state designed for the Avio ICP-OES series
		RF power range: 700-1500 W
		Most robust plasma on the market for running organics and aqueous
		Oscillator efficiency at 80%
	Plasma Source	Patented HeliPlate technology made of high-quality aluminum
		Air-cooled (chiller-free)
		No maintenance

Plasma Ion Source (continued)		
	Ar Gas Controllers	Computer-controlled solenoid valves. Run between 0-17 L/min in 1 L/min increments
	Plasma	8-17 L/min in 1 L/min increments (in operation)
	Auxiliary	0-2.0 L/min in 0.1 L/min increments
	Oxygen Gas Controller	3-200 mL/min in 1 mL/min increments
	PlasmaShear Gas	Compressed-air shear gas at 23 L/min that is used to remove the plasma plume and to keep the heat away from the optics. Nitrogen may also be used.
	PlasmaCam	Color camera allows real-time plasma viewing
	Plasma Ignition and Extinction	Computer-controlled and totally automated
	Cooling	No chiller needed. Instrument is air-cooled.
Spectrometer		
	Polychromator	Patented high-energy echelle-based polychromator
		6 pm of resolution at 200 nm, and 20 pm of resolution at 550 nm
		Spectral range from 167-900 nm
	UV Boost	Enhances signal-to-noise ratio for wavelengths < 243 nm
	Optical Coatings	Each reflective optic within the Avio 3000 system utilizes an optimized reflective coating designed to increase light throughput
		Each transmissive optic utilizes an optimized anti-reflective coating designed to decrease stray light throughout the entire system.
	Vertical Dual View Plasma	A vertically oriented plasma with complete dual-viewing optics under computer and software control
Detector		
	Detector	Full-frame backside-illuminated CMOS sensor
		Each region of interest (ROI) corresponds to an analyte and is read independently at its optimum integration time.
		The combination of simultaneous readings at the optimum integration time per analyte translates into improved precision.
		Able to read as fast as 4 microseconds for high-concentration samples
Software		
	System Operations	All analytical system operations (component optimization, methods development, calibration, analysis and reports) controlled using Syngistix for ICP software
	Automation	Syngistix software features automated system startup, shutdown, and wavelength alignment
	Ease of Use	Scheduled user-defined alerts for routine maintenance
		Automated quality control checking

Software (continued)		
	Ease of Use (continued)	Automatic Method Alignment
		QuickStart
		SmartQuant
	Analysis Options	Quantitative analysis:
		- External calibration
		- Additions (matrix matched) calibrations
		- Method of standard additions
		Semi-quantitative analysis
	Real-time Features	Real-time graphics with the ability to display transient and continuous signal profiles
		Real-time plotting of internal standard response in Results, plot exported with results
	Calibration Curve Fitting	- Linear least squares calibration fitting
		- Weighted linear least squares
		- Linear forced-through-zero least squares
		- Method of standard additions (matrix matched calibration)
		- Linear bracketing
		- Non-linear bracketing
	Quality Control	Multiple QC actions:
		- Analyst to define when and how an action is taken
		- Ability to specify a second QC action
	Interference Corrections	- Multicomponent Spectral Fitting
		- Inter-Element Corrections
	Data Processing	Data reprocessing for:
		- Changes of calibration points
		- Omit replicate
		- Curve fit mode
	Data Export	Single-click to export analytical data as a Microsoft® Excel® file
	Data Integrity	Method and data versioning

Smart Features		
	LED Status Light	Light is viewable 360 degrees for real-time instrument status
	Vent Flow	Constant monitor of vent flow
	Nebulizer Back Pressure	Constant monitor of nebulizer back pressure
	SmartRinse	Dynamic-rinsing function to eliminate carryover
	SmartQuant	A quantitative or semi-quantitative tool to monitor all wavelengths with visual display that quick and simple to understand
	QuickStart	A simple way to start analyses, in just three clicks
	Automatic Method Wavelength Alignment	Optimizes peak position and reduces day-to-day variation in instrument performance
Physical Data		
	Power	One 200-230 VAC, 20A line, 3200 VA, single-phase, 50/60 Hz ($\pm 1\%$)
	Dimensions	60 x 96 x 82 cm (W x H x D), 113 kg
	Environmental	The instrument will operate with a laboratory temperature between 15 and 35 °C (59-95 °F). For optimum instrument performance, the room temperature should be controlled at 20 $\pm$ 2 °C.