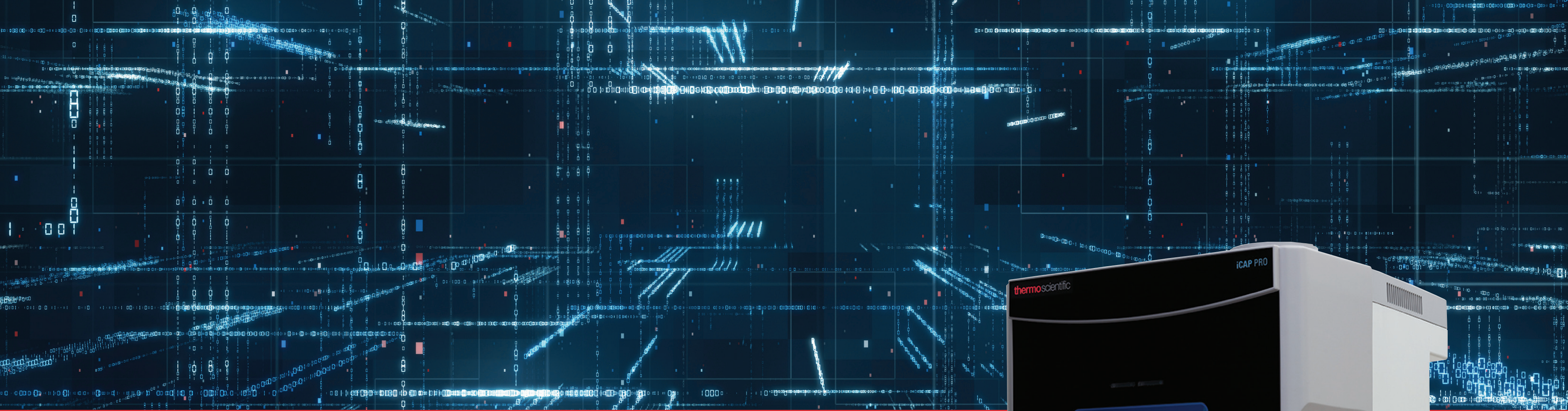

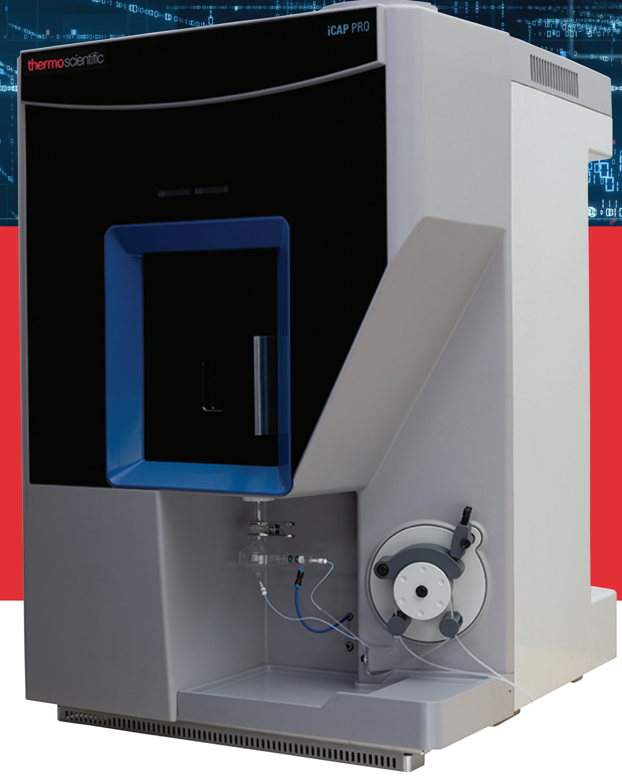

DEMONSTRATING STABLE ANALYSIS WITH THE THERMO SCIENTIFIC ICAP PRO SERIES ICP-OES

ICP-OES instruments have evolved rapidly in recent years. This evolution has been driven by the need for performing the measurements faster and improving the robustness of the technique.

Measurement stability in complex and challenging matrices is important alongside instrument uptime and a reduction in user maintenance. The Thermo Scientific™ iCAP™ PRO Series ICP-OES incorporates a vertical torch design, providing not only the smallest footprint ICP-OES on the market but also delivering unchallenged robustness.

A vertical torch orientation for a radial-only instrument is the industry standard; however, for a dual view instrument there are two major challenges that need to be addressed to ensure robustness. The first of these challenges is the deposition of sample matrix on the plasma interface, and the second is corrosion of the interface parts due to the introduction of potentially higher matrix samples. Both can lead to contamination, increased instrument maintenance, and high costs for replacement parts or servicing of the instrument. To reduce instrument downtime, the maintenance of the instrument should be easy to perform and as infrequent as possible.

All these aspects were considered when developing the new iCAP PRO Series ICP-OES.

Optical protection, sealing and temperature control

The iCAP PRO Series ICP-OES has a completely unique optical system designed specifically for it. This optical system is protected with a sealed housing. This housing has the smallest possible volume to ensure efficient purging as well as incorporating the latest in sealing technology around components, such as optical windows. When combined, these features result in an efficient high-performance optical system that leads to low purge gas requirements in standby mode as well as in operation.

The iCAP PRO Series ICP-OES has a Purged Optical Path (POP) that is designed to protect the fore-optics housing and mirrors. Quartz glass windows (two on a duo system and one on a radial system) are located in a fully sealed holder, which is placed between the plasma interface and the fore-optics (Figure 1). The POP windows are purged from both sides in order to prevent matrices from the samples entering the fore-optics. These windows can be easily removed and cleaned by the user as required.

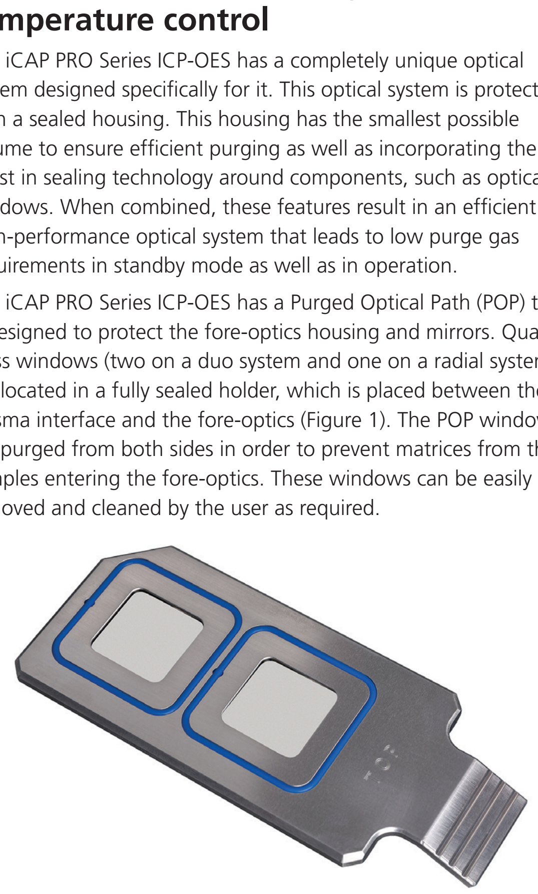

Figure 1: iCAP PRO Series ICP-OES Purged Optical Path window holder

To protect the fore-optics and to increase their lifetime, a beam blocker moves into the light path when no measurements are performed. This prevents the mirrors from being exposed to unnecessary UV radiation, increasing their lifetime.

To improve the mirror lifetime even further, stepper motors used to move optical components have been placed outside of the optical housing, and with this, the risk of contamination from these components is reduced. Placing these components outside of the optical tank also allows for easier and simpler servicing, leading to reduced instrument downtime.

The optical housing of the iCAP PRO Series ICP-OES is temperature controlled at 38 ± 0.1 °C. This allows for consistent measurement stability day after day as the influence of laboratory conditions on the instrument is minimized.

Figure 2: iCAP PRO Series ICP-OES EMT Torch

Robust vertical torch design

The vertical torch design of the iCAP PRO Series ICP-OES means that the low detection limits of the axial view can be achieved, while utilizing the high matrix tolerance associated with a radial plasma.

The robust Thermo Scientific ICP-OES Enhanced Matrix Tolerance (EMT) torch design has been improved for the iCAP PRO Series ICP-OES when compared to the EMT torch used with the Thermo Scientific iCAP 7000 Series ICP-OES. The mounting design of the torch holder and center tube holder allows for a more accurate and easy installation to ensure optimal performance and to avoid air leaks. The center tube holder is made of highly robust polyphenylsulfone (PPSU) material and has heat resistant O-rings installed to enable an airtight sealing (Figure 2).

For high-matrix, organic or even hydrofluoric acid measurements, the ceramic D-torch with a ceramic center tube can be used. The outer tube of the ceramic D-Torch is made from SiAlON, which is a ceramic material derived from silicon nitride. SiAlON is an extremely durable and strong ceramic material that is known to maintain its properties at high temperatures, making it an ideal material for an ICP torch. The intermediate tube is made from alumina, which also has excellent properties for chemical and temperature resistance.

Ceramic cones are placed between the plasma and the optical interface of the instrument (Figure 3). The ceramic cones are highly heat and corrosion resistant. To prevent sample matrix and heat from the plasma from entering the optical path of the system, a purge flow is guided through the optical path, exiting through the ceramic interface cone. The cones (one for radial system and two for a dual view system) can easily be removed, cleaned, and reinstalled by the user if required.

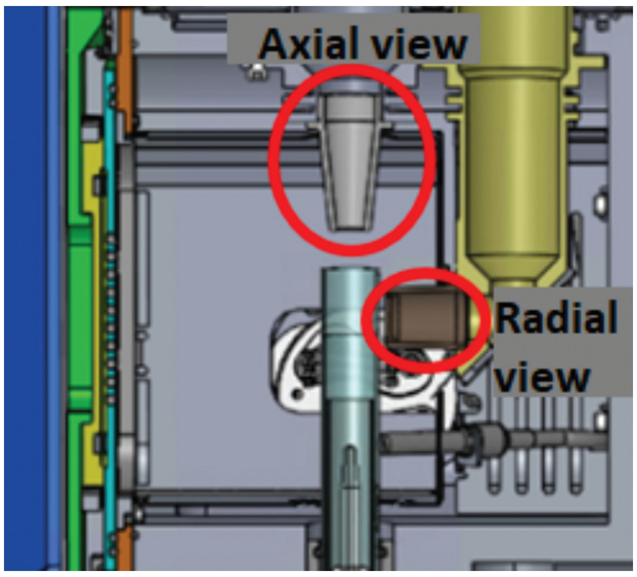

Figure 3: iCAP PRO Series ICP-OES vertical torch design with the location of the ceramic interface cones highlighted

The proprietary exhaust flow design of the iCAP PRO Series ICP-OES minimizes the demand on laboratory facilities and ensures the adequate cooling of the instrument electronics and torch box compartment without compromising analytical stability.

The iCAP PRO Series ICP-OES has an inner torch box that protects the plasma compartment from corrosion and contamination (Figure 4). This aluminum inner box can be easily removed and cleaned by the user if required.

The new vertical torch design of the iCAP PRO Series ICP-OES provides excellent detection capabilities with high matrix robustness and eliminates concerns regarding interface corrosion and excessive maintenance requirements.

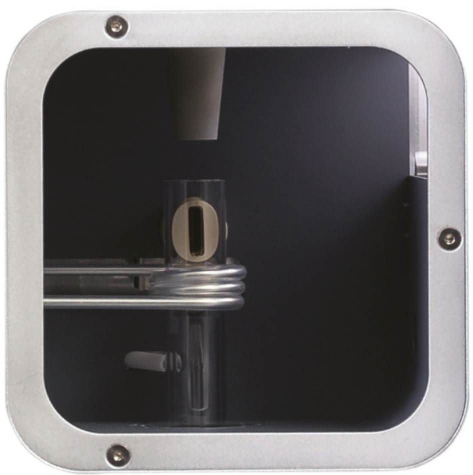

Figure 4: iCAP PRO Series ICP-OES duo torch box with inner torch box mounted

Long-term stability

A key indicator of the robustness of an ICP-OES is an assessment of long-term stability. To make this assessment of the iCAP PRO Series ICP-OES, a multielement solution (10 µg·L[-1] of Be, Cd, Cr, and Mn and 5 mg·L[-1] of Ag, Al, Ba, Cu, and Zn) was prepared from single element standards (1000 mg·L[-1], SPEX CertiPrep Group, Metuchen, US) in an acidic matrix (2% HNO_3, Fisher Chemical, Loughborough, UK). This solution was labeled stability test solution.

The axial view of the iCAP PRO Series ICP-OES was chosen for the assessment as it is the plasma view most likely to suffer any potential robustness issues. The method parameters used were the default parameters for aqueous analysis. The plasma was ignited, and the instrument allowed to warm up for a period of 15 minutes. The stability test solution was then analyzed over a period of 11 hours.

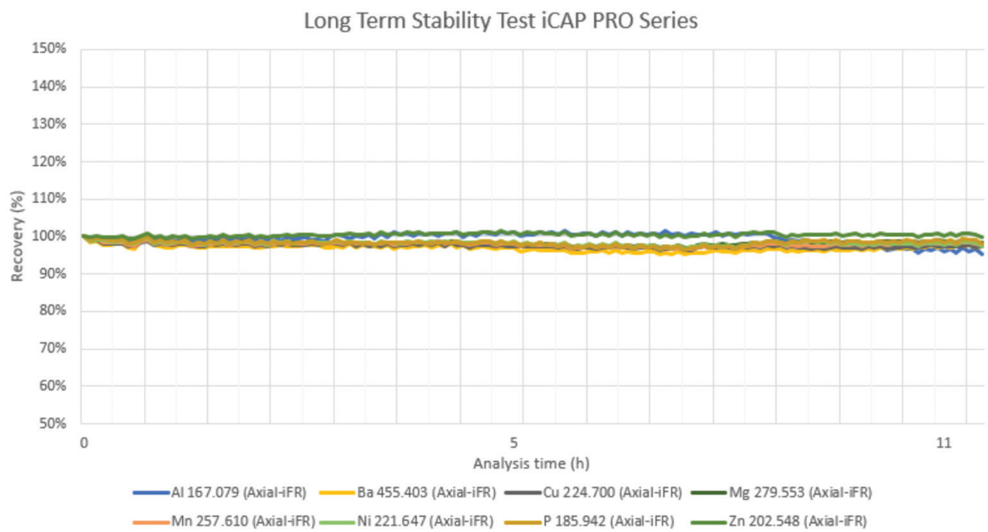

Figure 5: Recoveries of the analysis of the stability test solution over an 11-hour period

The recovery of each sample was calculated with respect to the first sample (Figure 5). Over the period of analysis, no drift correction of any type or internal standardization was applied. Figure 5 and Table 1 show that excellent long-term stability was achieved over the period of analysis with all recoveries within 5%. For the sample, an overall RSD (the RSD of all sample measurements) of ≤1.5% was achieved, and for all analytes the average RSD of the replicates was ≤0.5%.

Table 1: Recovery range, long-term overall RSD of all measurements, and average RSD of replicates for stated element wavelengths in %

Element and Wavelength (nm)	Plasma View	Recovery range (%)	Overall RSD (%)	Average replicates RSD (%)
Al 167.079	Axial	95.4–101.7	1.5	0.5
Ba 455.403	Axial	95.2–100	0.8	0.4
Cu 224.700	Axial	96.5–100	0.5	0.3
Mg 279.553	Axial	97.1–100	0.5	0.3
Mn 257.610	Axial	97.1–100	0.5	0.3
Ni 221.647	Axial	97.1–100	0.5	0.3
P 185.942	Axial	96.4–100.1	0.7	0.4
Zn 202.548	Axial	99.4–100.4	0.4	0.3

Conclusion

The iCAP PRO Series ICP-OES has been designed with the user requirements for robustness in mind. The features described above make the iCAP PRO Series ICP-OES highly robust, reducing the requirement of user maintenance and keeping instrument downtime to a minimum.

The features of the iCAP PRO Series ICP-OES that ensure robustness include:

- Vertical torch design, which ensures optimal performance and robustness for all instrument models
- Optical design and mirror protection to reduce routine maintenance
- Inner torch box for improved stability and ease of maintenance

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