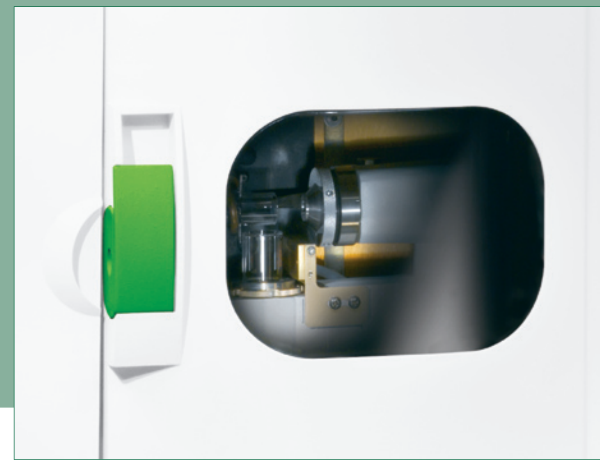
TECHNICAL NOTE

ICP-Optical Emission Spectroscopy

Optima 8x00 Series Dual View ICP – The Best of Both Worlds



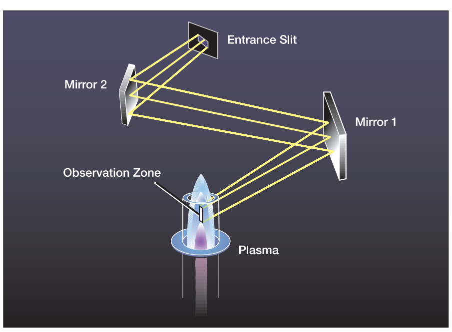


Figure 1a. Radially viewed plasma with a vertical slit image in the plasma.

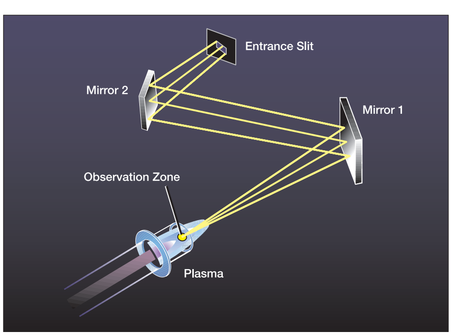


Figure 1b. Axially viewed plasma with a circular slit image in the plasma.

Radial or axial plasma viewing?

For over 20 years, analysts have been using radially viewed ICP-OES. The emission of interest occurs in the central channel of the plasma, and the spectrometer views the analyte emission from the side of the plasma through the background argon emission. Viewing height is a very important parameter with radially viewed plasmas because elements undergo emission at various heights in the plasma (usually expressed as height above the load coil). That's why the Optima™ 8x00 series ICP-OES spectrometers provide automated optimization of the viewing height.

For use with radially viewed plasmas, a spectrometer normally is designed to image a vertical slit in the plasma (Figure 1a). This vertical slit has the effect of averaging the analyte emission intensity over the height of the slit. In comparison, an axially viewed plasma system looks down the central channel of the plasma (Figure 1b) and collects all the analyte emission over the entire length of the plasma. The net effect is that the emission pathlength is increased relative to a radially viewed plasma. This increases the measured analyte emission and improves sensitivity. However, axial viewing does not extend the dynamic measurement range available. It merely shifts the range downward to encompass lower concentrations.

Radial viewing of the plasma complements axial viewing by providing an equivalent working range, but at higher concentrations. A system that provides both radial and axial viewing offers the advantages of both.

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Why not use alternate wavelengths to extend the working range?

The use of alternate, less sensitive wavelengths to extend the working range is a viable alternative in some instances. However, the use of multiple wavelengths for the same element also has potential drawbacks:

- Regulatory methods frequently specify that the analysis must be performed at a prescribed wavelength. Use of an alternate wavelength could mean that the analysis was non-compliant.
- Even with methods that allow the use of alternative wavelengths, those wavelengths must be evaluated for each sample matrix, increasing method development time. For example, the alternative line should be examined for potential interferences not found at the normal wavelength.
- Not all elements have multiple usable wavelengths with appropriately different sensitivities, e.g., sodium. What do you do when a satisfactory alternative wavelength isn't available?
- The use of alternate wavelengths requires extra calibrations to be performed at each additional wavelength, potentially increasing analysis times, particularly with sequential ICP systems.

The use of a system that can conveniently provide both axial and radial viewing eliminates these limitations.

Detection limit improvements

The improvement in sensitivity with an axially viewed plasma typically yields a 5- to 10-fold improvement in detection limits. This provides a powerful tool for environmental analysis, including many U.S. EPA and DIN methods. In fact, the Optima series ICP-OES systems in their axially viewed plasma mode meet the U.S. Environmental Protection Agency (EPA) Contract Required Quantitation Limits (CRQL) for all 22 elements in the protocol (CERCLA Statement of Work ILM05.3/ILM05.4 or ISM01.1). Without axial viewing, the detection limits for four of these elements previously required the use of graphite furnace atomic absorption (GFAA) or ICP mass spectrometry (ICP-MS).

With the Optima series and axial viewing, laboratory productivity is greatly improved because the number of sample preparations is reduced, data reduction is simplified and operator training is minimized. A single sample preparation is all that is required, saving time, minimizing reagent usage and reducing waste generation. Also, since all the results are acquired on a single instrument, report generation is simplified.

Reducing axially viewed plasma interferences by using a shear gas

The term self-absorption refers to the process whereby analyte emission is absorbed by ground state atoms in the plasma. With a radial plasma, this normally occurs at high analyte concentrations and results in a nonlinear calibration curve, limiting the useful analytical range for an analyte. Ground state atoms occur where the plasma is cooler, whether localized in the normal analytical zone or in the tail plume of the plasma.

Figure 4 (Page 3) shows a plasma with 5000 ppm yttrium being aspirated. The blue color is from normal emission and the red zone of the plasma is the cooler tail plume. Self-absorption occurs in this cooler part of the plasma. That is, emission from excited state atoms in the blue zone will be absorbed by the ground state atoms in the cooler red zone of the plasma. With the radially viewed plasma, this is not a problem since the tail plume is not in the optical path.

To eliminate the adverse effects of this cooler tail plume, the axially-viewed Optima configurations use an air shear gas to displace the tail plume out of the optical path (Figure 5 – Page 3). This elegantly simple solution provides a number of real advantages. First, compressed air is normally available in most laboratories, so no additional costs are incurred. Second, the plume is displaced before it approaches the entrance to the optical system, minimizing the possibility of corrosion to or sample deposition on any optical system component.

As can be seen in Figure 6 (Page 3), the red tail plume is eliminated and a very thin boundary is created by the shear gas. By comparing Figure 4 and Figure 6, you can see the differences in the optical path length of the red areas of the two plasmas. The Optima ICP series with the air shear path ensures that you will have the largest linear dynamic range possible with axially viewed plasmas.

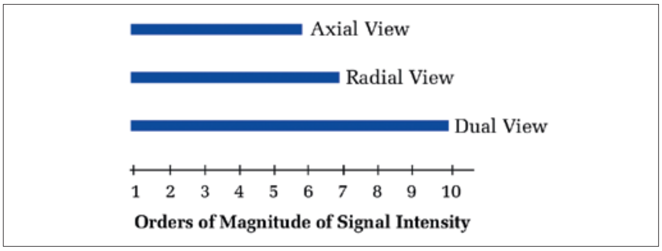

Figure 2. Typical analytical working ranges for the inductively coupled plasma technique.

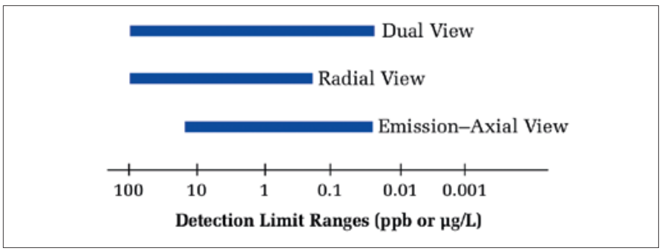

Figure 3. Typical detection limit ranges for inductively coupled plasma viewing modes.

The best of both worlds

Unfortunately, neither viewing configuration – radial or axial – is perfect for all needs. That's why the Optima 8x00 series spectrometers include the patented Dual View (DV) configuration (U.S. Patent No. 5,483,337). With the DV system, a software-controlled mirror provides the operator with a simple means of selecting the desired viewing mode. In fact, the viewing mode can be included as a part of the operating method for each analyte. Careful attention has been paid to the size and shape of the slit and the size of the location of the viewed image to optimize the analyte intensity and minimize the background emission with both configurations.

The Optima 8x00 series ICP-OES spectrometers with Dual View truly offer the best of both worlds.

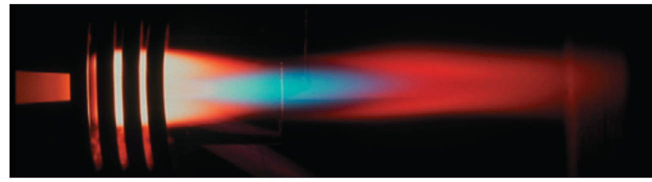

Figure 4. Yttrium plasma with the blue color showing the normal emission and the red color showing the cooler tail plume.

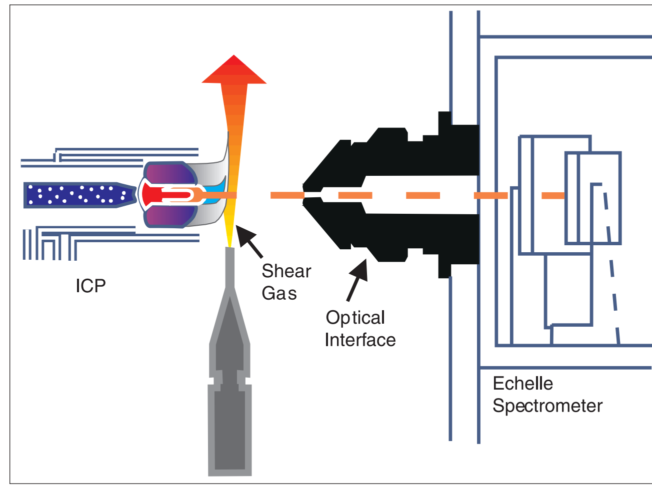

Figure 5. Air shear gas used with the axially viewed plasma of the Optima.

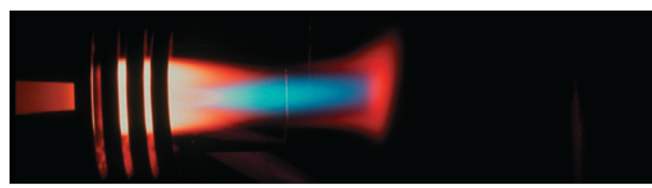

Figure 6. Yttrium plasma with the blue color showing the normal emission and the red color showing the cooler tail plume displaced by the air shear gas.

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