

What goes into the decision-making process when one chooses between AA and ICP? Is the determination made because of cost, the user's knowledge level, multiple detection needs, etc?

(Barnes) The first requirement is which elements are needed and their concentration ranges. Flame AA is for one (to maybe eight elements that work very well) superior to ICP-OES in terms of sensitivity. However, ICP is faster, more cost effective, and safer. For typical routine operations, ICP and AA are equally easy to use. For ultratrace analysis, furnace AA should be compared to ICP-MS, and the trend is to replace AA with ICP-MS because of the much better sensitivity, faster analyses, lower costs, and easier sample manipulation. Unaware users or buyers might select AA first, because of its lower capital costs, but overall ICP-MS is more cost effective and provides superior results.

(Frame) A Zeeman graphite furnace atomic absorption spectrometer costs about half of what a high throughput axial or dual-view ICP costs. But if an AA instrument is being purchased, it is not for its low cost, but for a specific single element detection need, such as large numbers of samples for blood lead determinations. Despite my personal attachment to AA as an analytical technique, it is slow and prone to chemical interference compared with ICP or ICP-MS.

(Pfiel) There are lots of factors: purchase price, operator expertise, analytical requirements — detection limits needed, number of elements analyzed, supplies, etc., preferred methodology, and comfort level.

(Shrader) Of course many factors affect the decision-making process and the end result is a balance that provides the best overall solution to the particular customer. Factors include sample type, analytical performance required (DLs and precision), required throughput (number of samples and analytes), operator skill, capital cost, and operating cost.

For example, one would choose flame AA or ICP for higher concentration analytes; one would choose furnace or vapor generation AA, axial ICP or ICP-MS for trace levels. If one has many analytes to determine in a large number of samples, simultaneous ICP or ICP-MS would be the technique of choice. Some elements are less prone to interferences using particular analytical techniques. Capital and operating costs are always a very important part of every decision. A small lab with limited sample load may not be able to justify the cost of an ICP or ICP-MS and decide to purchase a flame/furnace/vapor generation AA system.

In many instances everything cannot be accomplished with a single instrument. Our sales representatives are there to partner with the customer, making sure the final decision is a solution, not just the lowest cost "answer". All Rights Reserved. Advanstar Communications Inc. 2005

In 2006, the US will introduce new regulations pertaining to arsenic (As) levels in drinking water. It is assumed this will boost ICP usage. First, is this assumption correct? And secondly, do you foresee any future situations that would boost either AA or ICP usage?

(Barnes) Yes, arsenic in drinking water may boost ICP usage, but total As determination by ICP may not be the best approach. The big impact on future usage is based on speciation analysis of metals and non-metals, wherein separation of chemical species, typically by chromatographic techniques, precedes the ICP-MS determination. For example, identification and quantification of the chemical forms of As in drinking water, foods, drugs, etc. is far more important than total As concentrations.

(Frame) I think most labs already use ICP or ICP-MS for As. Some use or have used Atomic Fluorescence Spectroscopy for both As and Se using hydride generation. This was popular prior to the current generation of reaction cell ICP-MS instruments that minimize the polyatomic interferences on As and Se.

(Pfiel) There is an arsenic rule that must be investigated to determine this legislation's impact.

(Shrader) I don't think the lowering of allowable arsenic levels in drinking water from 50 µg/L to 10 µg/L will give a large boost to ICP usage per se. Labs currently using ICP for arsenic determinations will continue to do so, however, they will require axial ICP capability. Alternately, they could add an ultrasonic nebulizer to improve their DL for arsenic. Labs currently using graphite furnace or vapor generation AA will continue to do so as either atomization technique can easily meet the new regulatory level requirement.

Globally, AA and ICP usage will continue to grow as emerging economies become "mainstream." Environmental consciousness is growing around the world and as governmental regulation increases, so will the demand for trace metal determinations, i.e., the need for more labs with AA and ICP capabilities. It doesn't stop at environmental issues however. More and more we are seeing the need for major and trace metal analysis in every aspect of our lives — agricultural, foods, beverages, mining, pharmaceuticals, petrochemicals, and energy — as consumer and regulatory pressures increase.

In the current marketplace, how would you compare the costs for ICP and AA instrumentation? Do you foresee any significant changes in the near or distant future?

(Barnes) ICP is almost always less expensive than AA when multiple element determinations are made. For example, it might cost \$2.50 for each sample (single element) by AA and \$3.50 for ICP, but with ICP you might determine 20 elements (\$0.18 per element). ICP instrument manufacturers are looking for ways to reduce instrument costs and introduce lower priced instruments.

(Frame) AA is half the cost of ICP-OES. Both techniques have significant consumables costs. I am afraid that there is not going to be a long-term market for high-end AA systems for environmental analytical requirements.

(Pfiel) I expect prices to continue to drop for AA and ICP, including ICP-MS.

(Shrader) Normal progression of costs is AA is less than ICP, and ICP is less than ICP-MS. Exact cost varies with accessories added (such as a graphite furnace), model (for example, sequential or simultaneous ICP) and amount of automation provided. One can purchase a basic AA for less than \$15,000. A basic sequential ICP may cost less than \$60,000 and ICP-MS will start at around \$125,000. So, there is a broad price range that goes along with the broad capability range offered by the different atomic spectroscopy techniques.

Operating costs follow the same trend — AA is less than ICP, and ICP is less than ICP-MS. However, when sample throughput and large number of analytes are considered, the simultaneous ICP and ICP-MS techniques may in fact provide lower costs/determination.

I don't see any significant changes coming. There will continue to be efforts made to improve instrument performance, productivity, and automation while reducing manufacturing costs, but these will be smaller changes over the long term.

When taking into consideration technological advances and/or limitations, industry demands, application segmentation, and the emergence of other techniques, how would you forecast the future for ICP and AA when it comes to usage in environmental testing?

(Barnes) ICP (both OES and MS) will be the dominant approach for environmental testing in the future.

(Frame) AA is used and will continue to be used in blood lead labs, municipal water testing labs (effluent testing), and some clinical labs. Most major commercial environmental labs will be moving to ICP-MS, if they haven't already done so.

(Pfiel) I expect AA will continue to be the preferred technique when the number of elements to be determined is very small and for small labs with limited budgets. ICP should be preferred for applica-

tions where the number of analytes exceeds two or three as long as it can achieve the required detection limits.

(Shrader) As stated earlier, the use of ICP and AA in emerging economies will continue to grow for environmental testing. I don't see major changes in developed markets such as North America and Europe. We will continue to see some shift in the ratio of plasma-based instruments to AA instruments, but there will always be a significant part of the environmental testing load that continues to be handled with traditional AA techniques.

How does ICP and AA usage in North America differ from that in regions such as Europe, Asia, and Latin America?

(Barnes) The differences are related to the level of industrial technology in these regions. For high-tech regions such as Europe, Japan, Korea, and Brazil, comparable usage is apparent versus North America. For developing countries, low-cost approaches (AA) are preferred because of the availability/costs of instrumentation, supplies, and argon gas. Only in leading institutes/industries with sufficient funding will ICP be used routinely. A strong correlation exists with government regulations (e.g., environmental controls) and the value-added costs. Again instrument manufacturers have a good view of exists and potential markets for AA versus ICP.

(Frame) I have no data on which to base an answer, but feel that Europe has been ahead of the U.S. in moving to performance-based analyses, where the instrument doesn't matter, as long as the data meet the regulatory requirements. I think ICP-MS will be the primary instrument for environmental labs, with ICP-OES used for "dirty" samples and high concentration analytes.

(Pfiel) Outside the USA limited power and argon supplies may shift the preferences slightly toward AA.

(Shrader) Market segment differences are seen in different countries/areas around the world but in general, ICP and AA usage in NA and Europe are very similar. These are well-developed, mature markets that will continue to slowly evolve.

Major growth is being seen in Asia and Pacific Rim countries. Though smaller, we also are seeing growth in Latin America and Africa. These areas tend to be in a different phase of the instrumental technique cycle, with AA growing much more rapidly than ICP or ICP-MS. As these markets mature, we will see some shift toward more plasma-based instrumentation. However, this shift will probably not be as significant as in North America and Europe because availability and expense of argon used to support the plasma will continue to be a limiting factor in these areas.

While both are widely used in environmental analysis applications, in the future, are there any other applications you can see ICP and/or AA being used in more?

(Barnes) Yes, the applications are really unlimited: geology, biology, agronomy, semiconductors, etc. have routinely used the techniques for many years and will be increasingly used. As new techniques are developed and commercialized based on ICP-MS, the number of application areas will continue to grow: speciation, biotechnology, country of origin identification, and forensics are but a few.

(Frame) I can't imagine an industrial research laboratory not having AA, ICP, and ICP-MS instruments. AA has very significant advantages for single-element quantitative analysis. While the technique did not prove to be a commercial success, slurry sampling and AA determination of materials was a method I used extensively. Slurry sampling does not work as well with ICP. Solid samples of polymers and similar materials can be analyzed directly in a graphite furnace AAS, much more rapidly than by dissolution, ashing and ICP, if only one or two elements need to be determined. Flame AA still has advantages if the alkali metals are a primary analyte. I think industry will continue to use AA, but will also use ICP and ICP-MS for their particular advantages.

(Pfiel) I do not see particularly new markets emerging but many other applications should continue to use both techniques. Some of the key markets are chemicals, petroleum, oils, clinical, etc.

(Shrader) Increased consumer, health, and regulatory pressures will drive future applications and lead to further use of ICP and AA. More and more we see the need for major and trace metal analysis in every aspect of our lives — agricultural (fertilizers), foods and beverages (nutritional labeling), mining (assays), manufacturing (QA/QC), pharmaceuticals (QA/QC), clinical diagnostics (electrolytes, nutrients and toxics), petrochemicals (additives, contaminants), semiconductors, and energy — along with environmental testing. AA, ICP, and ICP-MS will be the methods of choice for these applications for years to come.



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