Technical Note: 40990

Reducing Operating Costs in your Laboratory with the Thermo Scientific iCAP 6000 Series ICP-OES

Key Words

- ICP, ICP-OES, ICP-AES
- iCAP 6000 Series
- Cost savings
- Argon gas
- Productivity

Summary of key points:

- The Thermo Scientific iCAP 6000 Series ICP-OES uses lower gas flow rates than other ICP instruments and could reduce argon gas costs by as much as 42%
- Ultra fast data acquisition and a range of productivity enhancing features are employed to reduce conventional 3 minute sample analysis regimes by as much as 75%
- The reduced gas consumption and high speed sample analysis capabilities produce very significant operating cost savings for your laboratory.

Introduction

Trace elemental analysis has a presence in most analytical laboratories covering a wide range of applications from the analysis of water to crude oil. Despite these differences, one thing all laboratories have in common is the need to provide a cost effective service to their clients. We understand the pressure your laboratory is under to produce efficiency savings, productivity increases and cost reductions. In the current economic climate, the pressure is greater than ever. Of course, there are many ways in which a laboratory can improve cost-efficiency, the most frequently considered of which is effective sourcing of goods and services. However, a certain amount of resource is required to investigate the available alternatives for sourcing and the cost savings produced are often relativity small. Assuming that sourcing approaches have already been explored in your laboratory, what other approaches are available to enable improvements in cost-efficiency? An approach that can offer significant savings is to increase the productivity of the laboratory and reduce operating costs as far as possible. Investment in instrumentation that has been designed with cost efficiency in mind can dramatically reduce costs over the life time of the instrument.

Dramatic running cost reductions

The Thermo Scientific iCAP 6000 Series ICP-OES has been designed to deliver inherently low running costs and offers a range of tools that help increase the productivity of your trace elemental analyses. This section discusses these cost-efficiency features.

Size matters

The iCAP 6000 Series ICP-OES is the most compact ICP-OES instrument available. The most obvious advantage of this is that valuable lab space can be used for other purposes and can mean that two instruments can fit into the space previously occupied by one. Although it is difficult to quantify these savings, it suffices to say that they could be significant since two iCAP 6000 Series ICP-OES instruments can fit in the same space as any of our competitor's models. The small footprint of the instrument is made possible by the compact nature of the components of the iCAP 6000 Series ICP-OES such as the polychromator and radio frequency (RF) plasma generator. The size reduction of these components was enabled by advanced engineering and design techniques such as computational fluid dynamics, finite element modeling and state-of-the-art computer aided design.

Low service and consumables costs

Efficient service is essential for any laboratory running an ICP-OES, particularly in a production environment. Service contracts can keep downtime to an absolute minimum, getting your instrument productive again as soon as possible when there is a problem, as well as reducing the occurrence of problems by the provision of preventive maintenance. We endeavor to keep our service costs as competitive as possible and the iCAP 6000 Series ICP-OES allows this thanks to its excellent reliability record. The cost of instrument consumables, such as replacement nebulizers, spraychambers and torches is also a factor to consider and the iCAP 6000 Series ICP-OES has design features that help to reduce the cost of replacement items. For example, our semi-demountable EMT torch only requires periodic replacement of the torch body and centre tube components, which are less expensive than replacing an entire torch. Ensuring the competitiveness of our service and consumables pricing helps your lab keep these costs to a minimum.

Operating cost reduction by design

The major operating costs associated with ICP-OES instruments are argon gas consumption and electric power consumption. Argon and electricity costs vary widely, even within countries, so exact cost estimations can be problematic. Table 1 shows the results of a small survey which gives some indicative costs for some European countries and regions of the United States, which were representative of market prices at the time of writing. These figures can be used as the basis of running cost estimations and comparisons.

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Country	Cost of liquid argon per liter	Cost of electric power per kWh	Currency
France	3.19	0.07	€
Italy	2.24	0.17	€
Netherlands	1.73	0.07	€
UK	1.50	0.12	£
USA - IL	1.74	0.09	$
USA - MD	1.96	0.14	$
USA - CA	6.00	0.14	$
USA - MA	1.96	0.16	$

Table 1: Some indicative costs of liquid argon and electricity. Costs were accurate reflections of market prices at November 2008.

Argon is used for the plasma gas flows of an ICP-OES and is also often used to purge the optical path of the instrument to remove air. An obvious way to reduce ICP-OES running costs is therefore to reduce the amount of argon that is used. This can be achieved in two ways:

1. By designing an instrument that consumes argon at a reduced rate; or
2. By decreasing the time that the instrument spends consuming argon, i.e. make the analytical process faster.

A combination of both of these approaches was the driving philosophy for the operating cost reductions produced with the iCAP 6000 Series ICP-OES.

The iCAP 6000 Series ICP-OES typically uses a flow rate of only 12 L/minute of argon for its main plasma gas flow, compared to a typical flow rate of 15 L/min for most other ICP-OES instruments. All ICP-OES instruments typically use about 1 L/min for both auxiliary and nebulizer flows. With the saving in the main plasma gas flow rate taken into account, significant savings in argon consumption are made with the iCAP 6000 Series ICP-OES, as shown in Table 2.

	Total Plasma	Litres of Liquid Argon Consumed Per Week							
	Gas Flow Rate	No. Hrs Usage/Week							
Instrument	(L/min)	10	30	50	70	90	110	130	150
iCAP 6000 Series ICP-OES Typical	14	10	30	50	70	91	111	131	151
Typical ICP-OES Competitors	17	12	37	61	86	110	134	159	183

Table 2: A comparison of typical plasma gas flow rates for iCAP 6000 Series and competitor products, showing the consumption in liters of liquid argon for various usage rates. Source for competitor flow rates: typical running parameters from application notes.

In addition to the low plasma gas flow rates, the Thermo Scientific iCAP 6200 ICP-OES model uses a plasma interface gas flow of just 1 L/min during operation with no requirement to purge the optical pathway at any time. The Thermo Scientific iCAP 6300 ICP-OES and Thermo Scientific 6500 ICP-OES models use just 3 L/min of gas to purge the optical path during operation and 1 L/min when the instrument is in standby mode. The use of such low gas flow rates is enabled by the small volume of the polychromator, the unique gas distribution system and the innovative plasma interface design. The gas flow system employed by the iCAP 6000 Series ICP-OES uses a distribution system which is much more efficient than traditional single-point distribution systems.

Other commercially available ICP-OES instruments use purge gas flows of 3.5 L/min or 7 L/min and some use as much as 11 L/min whilst operating. As can readily be seen, the gas saving is considerable. Although nitrogen can be used as a less expensive alternative, argon is frequently used as a purge gas for ICP-OES instruments to avoid the necessity for the installation of additional gas lines and to avoid the rental of additional gas tanks. Since argon is a relatively expensive gas, any small reduction in the flow rate used can bring about significant cost savings. Table 3 gives some example gas usage rates for the iCAP 6000 Series ICP-OES instruments and two competitor ICP-OES instruments for various usage scenarios. It can be seen from Table 3, that the apparently modest change in plasma interface/purge gas flow rates actually makes a significant difference to the volume of liquid argon consumed per week.

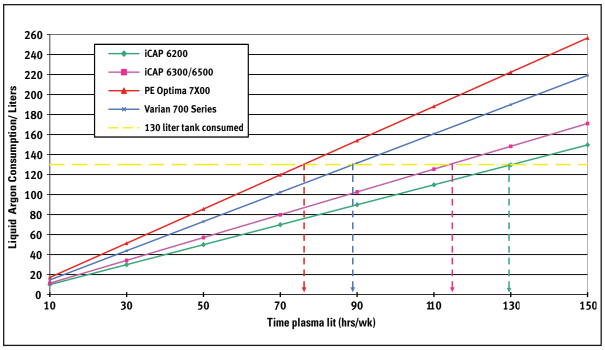
	Plasma Interface	Liters of Liquid Argon Consumed Per Week							
	/PurgeFlow Rate	No. Hrs Usage/Week							
Instrument	(L/min)	10	30	50	70	90	110	130	150
iCAP 6200	1 (1)	1	2	4	5	6	8	9	11
iCAP 6300/6500	3 (1)	2	7	11	15	19	24	28	32
PE Optima 7X00	7 (1.4)	5	15	25	35	45	55	65	75
Varian 700 Series	3.5 (3.5)	3	8	13	18	23	28	33	38

Table 3: A comparison of plasma interface/purge gas flow rates for iCAP 6000 Series ICP instruments and two competitor products, showing the consumption in liters of liquid argon for various usage rates. Source of competitor instrument values: instrument preinstallation guides. Values in parentheses reflect gas flows when instruments are 'idle' - for reference only).

With these two major savings of argon gas consumption taken together, the total savings in argon are considerable, as shown in Table 4. These figures are also shown graphically in Graph 1, which indicates the number of hours that the instruments could be operated for with a single 130 liter tank of liquid argon: 76, 89, 114 and 130 hours for PE Optima 7X00, a Varian 700 Series, Thermo Scientific iCAP 6300/6500 and Thermo Scientific iCAP 6200 ICP-OES spectrometers, respectively. Looked at from the cost perspective for a given number of hours of usage, iCAP 6000 Series ICP-OES instruments are able to provide argon gas cost savings of up to 32% compared to a Varian 700 Series ICP-OES spectrometers and up to 42 % compared to PE Optima 7X00 spectrometers.

	Liters of Liquid Argon Consumed Per Week							
	No. Hrs Usage/Week							
Instrument	10	30	50	70	90	110	130	150
iCAP 6200	10	30	50	70	90	110	130	150
iCAP 6300/6500	11	34	57	80	103	125	148	171
PE Optima 7X00	17	51	86	120	154	188	222	257
Varian 700 Series	15	44	73	102	131	161	190	219

Table 4: A comparison of typical total argon consumption for iCAP 6000 Series ICP instruments and two competitor products, showing the consumption in liquid liters of argon for various usage rates (calculated from data given in the tables above).



Graph 1: A comparison of typical argon gas usage for the iCAP 6000 Series ICP-OES and competitor instruments A and B, indicating the number of hours usage at which a typical 130 liter liquid argon tank would be consumed.

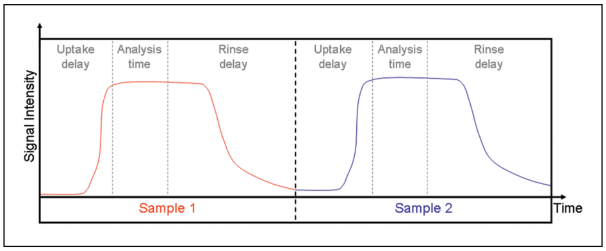


Figure 1: A typical automated sample analysis profile: Autosampler probe moves to Sample 1 – uptake delay while sample travels to plasma and stabilizes. Analysis time during steady-state signal period. Probe moves back to rinse station – rinse delay while rinse solution travels to plasma and washes out sample introduction system. Probe moves to Sample 2 and the cycle begins again. The figure shows how the productive analytical section is typically only a small percentage of the total cycle – much of the cycle time is taken up by non-productive delay times.

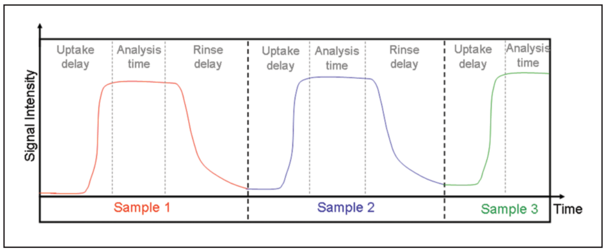


Figure 2: An automated analysis profile using step-ahead autosampling: Autosampler probe moves to Sample 1 – uptake delay while sample travels to plasma and stabilizes. Analysis time during steady-state signal period. Probe moves back to rinse station during the analysis using the remaining sample in the uptake line to complete the analysis. The sample line is already primed with rinse solution when the analysis ends, considerably shortening the rinse delay. Probe moves to Sample 2 and the cycle begins again. The figure shows how the non-productive sections are significantly reduced and how more samples can be analyzed per unit time in comparison with Figure 1.

Cost reduction from productivity increase

As already discussed, ICP-OES instruments use considerable quantities of argon. Using traditional torch designs this cannot be avoided, but the time for which the plasma gas flows are in use can be reduced with concomitant operating cost reductions. Reductions in sample analysis time will also have a positive effect on the second highest operating cost associated with an ICP-OES: energy costs. The iCAP 6000 Series ICP-OES has a number of tools that can be used to expedite the analysis and a number of design features that make it inherently faster at analyzing samples.

The first step in speeding up an analysis is to use an autosampler and significant productivity-enabled cost reductions can be achieved with the iCAP 6000 Series ICP-OES simply by using standard accessories such as the CETAC ASX 520 or ESI SC-4 autosamplers. This allows unattended analysis of your samples and ensures that samples are analyzed in the correct sequence, in the most time-efficient manner. Furthermore, the Thermo Scientific iTEVA Software offers intelligent control of the autosampler with a feature called Autosampler Step-Ahead. This feature allows the autosampler to move to the rinse station or to the next sample, using the sample solution remaining in the uptake tubing to complete the analysis whilst the rinse solution, or the next sample, is primed in the sample line. This typically reduces the analysis time by approximately 40 seconds, which for a 3 minute analysis time per sample, represents a saving of 22% per sample analysis. Figures 1 and 2 indicate typical analytical cycles – sample uptake, analysis, and rinse – and indicate how Step-Ahead autosampling can significantly increase sample throughput by reducing the non-productive parts of the cycle.

Once the sample has reached the plasma, one of three powerful data acquisition modes is used to address the performance requirements for all application areas effectively; Precision, Speed and the new, ultra fast Sprint data acquisition mode (available on iCAP 6500 ICP-OES instruments).

The new Sprint mode enables ultra high-speed trace element screening for the most demanding high-throughput laboratory environments. This mode can be used in conjunction with standard or advanced auto-sampler accessories such as ESI SC FAST systems to reduce typical sample analysis times from 3 minutes down to as low as 45 seconds per sample. These productivity enhancements can equate to a time saving of up to 75% for analyses comprising an equivalent number of replicate measurements per sample and for a multi-element run spanning the full wavelength range.

The iCAP 6500 ICP-OES also offers further speed-enhancing features such as an automated fast pump speed for accelerated uptake reducing the sample uptake time by around 50% and intelli-rinse (IRINSE) to intelligently monitor the rinse cycle. IRINSE ensures complete washout of ‘sticky’ elements by adapting the rinse time to ensure the levels of analyte elements fall below a user defined level before moving to the next sample. These features can help further improve the speed of analysis when using selected liquid autosampler accesories and IRINSE can help reduce the number of samples requiring reanalysis by reducing contamination due to carry over.

Collectively, the inherently low gas usage and the productivity enhancements of iCAP 6000 Series ICP-OES instruments can produce dramatic running cost savings when compared to other ICP-OES instruments in the market. When added up over the lifetime of the product, these savings can be enormous.

Illustration of Lifetime Cost Savings

The operating lifetime of the average ICP-OES instrument in a typical contract laboratory environment could be taken as 10 years. Over the course of this period, the costs of running the instrumentation are considerable. The following illustration is intended to highlight why you should carefully consider the running costs of an ICP at the time of selection and demonstrates that the ongoing operating costs are extremely important in addition to the up front instrument purchase costs.

Hypothetical example

A moderate throughput contract laboratory is considering a replacement ICP purchase. The laboratory runs 100 samples per day for 5 days of the week with a multi-element method that requires 3 replicate measurements per sample and takes 3 minutes per sample on their current ICP-OES. The operator leaves the plasma on for an average of 1 hour per day prior to starting the run, meaning that the plasma is operated for 30 hours per week. In this example, the iCAP 6500 ICP Spectrometer is shown to provide productivity enhancing features to enable analysis of 100 samples in approximately 75 minutes (when using advanced autosampler accessories such as ESI SC FAST systems). This translates to a requirement for the plasma to be operated for <12 hours per week in comparison to the current described 30 hour regime.

The general and productivity-enabled cost savings delivered by an iCAP 6500 ICP-OES are in the region of $10,000-41,000 during the lifetime of the product when compared with two competitor ICP instruments (see Table 5 for further details). These cost savings are calculated solely from gas and power consumption rates associated with the above described analysis regime. Further potential savings which may be associated with reduced service costs and reductions in non-productive down time, which could also be considerable when compared with older ICP instruments are excluded here. These described cost savings could justify and off-set the up front purchase costs of a second iCAP 6000 Series ICP-OES significantly if required.

Costs ($)	iCAP 6500	PE Optima 7X00	Varian 700 Series
Lifetime argon gas costs ($)	20010	29273	57921
Lifetime electricity costs ($)	2148	2711	6043
Lifetime total running costs ($)	22158	31984	63964
Savings from iCAP 6500 versus competitor ICP ($)	-	**9827**	**41806**

Table 5: Estimated lifetime (10 year) running cost savings from an iCAP 6500 ICP-OES compared with two common competitor ICP-OES products. Note these figures do not take inflation into account and fix argon and electricity prices across the 10 year period. Inflation will actually make the savings realized by the iCAP 6000 Series ICP-OES even larger. Source for speed of analysis and electricity consumption data used in calculations for competitor products: Application Notes, Manuals and Pre-Installation Guides.

Conclusions

By design, Thermo Scientific iCAP 6000 Series ICP-OES provides very significant cost savings through efficient argon and electricity consumption. Furthermore, total time savings of up to 135 seconds per analysis (~75% saving for a typical 3 minute analysis) can be achieved. These time savings are possible as a direct result of the instrument analyzing samples faster and through ICP instrument operation with innovative liquid sample introduction accessories that are optimized for high throughput capability. As a result of the above, the instrument will consume proportionately less gas and power, providing associated cost savings compared to other competitor ICP products on the market. The Thermo Scientific iCAP 6000 Series ICP-OES could help your lab reduce its argon costs alone by as much as 42% for a typical production multi-element analysis. This proves that even in tough economic times, it pays to invest in a Thermo Scientific iCAP 6000 Series ICP-OES.

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