

# Guide to Atomic Spectroscopy Techniques and Applications

**AA**  
**GFAA**  
**ICP**  
**ICP-MS**



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Atomic spectroscopy has experienced remarkable growth and diversification in the past decade. This publication is designed to provide a quick reference to the major atomic spectroscopy techniques and how they can be used to solve analytical problems. Included is a section on the fundamentals of atomic spectroscopy, a bibliography listing selected articles on various applications, and a description of PerkinElmer's complete line of atomic spectroscopy instrumentation and accessories. Reprints of the articles listed in the bibliography are available free of charge (see Section 2). For more information contact your local PerkinElmer representative, fill out and mail or fax the attached business reply card, visit our website at: [www.perkinelmer.com](http://www.perkinelmer.com), email us at: [info@perkin-elmer.com](mailto:info@perkin-elmer.com), call (+1) 203-762-4000 or 800-762-4000, or Fax (+1) 203-762-4228.

## WHAT IS ATOMIC SPECTROSCOPY?

Atomic spectroscopy is actually not one technique but three: atomic absorption, atomic emission, and atomic fluorescence. Of these, atomic absorption (AA) and atomic emission

are the most widely used. Our discussion will deal with them and an affiliated technique, ICP Mass Spectrometry.

## WHAT IS ATOMIC ABSORPTION?

Atomic absorption is the process that occurs when a ground state atom absorbs energy in the form of light of a specific wavelength and is elevated to an excited state. The amount of light energy absorbed at this wavelength will increase as the number of atoms of the selected element in the light path increases. The relationship between the amount of light absorbed and the concentration of analyte present in known standards can be used to determine unknown concentrations by measuring the amount of light they absorb. Instrument readouts can be calibrated to display concentrations directly.

The basic instrumentation for atomic absorption (Figure 1) requires a primary light source, an atom source, a monochromator to

isolate the specific wavelength of light to be used, a detector to measure the light accurately, electronics to treat the signal, and a data display or logging device to show the results. The light source normally used is either a hollow cathode lamp or an electrodeless discharge lamp.

The atom source used must produce free analyte atoms from the sample. The source of energy for free atom production is heat, most commonly in the form of an air-acetylene or nitrous oxide-acetylene flame. The sample is introduced as an aerosol into the flame. The flame burner head is aligned so that the light beam passes through the flame, where the light is absorbed.

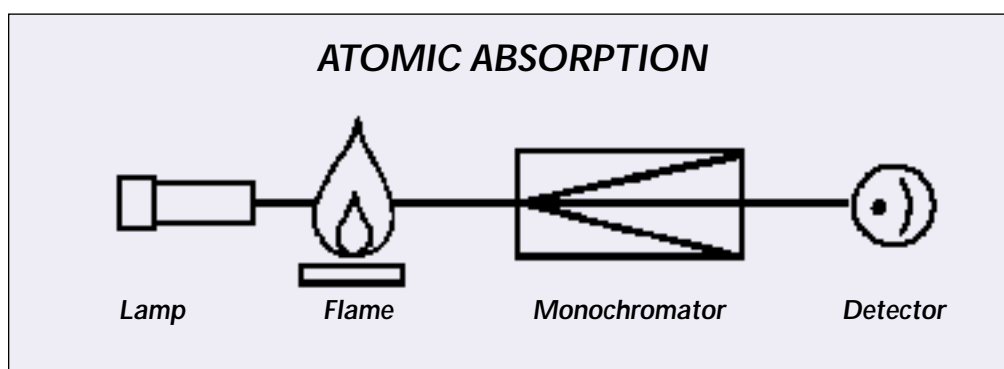


Figure 1. Simplified drawing of a basic flame atomic absorption system.

## WHAT IS GRAPHITE FURNACE ATOMIC ABSORPTION?

The major limitation of atomic absorption using flame sampling (flame AA) is that the burner-nebulizer system is a relatively inefficient sampling device. Only a small fraction of the sample reaches the flame, and the atomized sample passes quickly through the light path. An improved sampling device would atomize the entire sample and retain the atomized sample in the light path for an extended period to enhance the sensitivity of the technique. Electrothermal vaporization using a graphite furnace provides those features.

With graphite furnace atomic absorption (GFAA), the flame is replaced by an electrically heated graphite tube. Sample is introduced directly into the tube, which is then

heated in a programmed series of steps to remove the solvent and major matrix components, and then to atomize the remaining sample. All of the analyte is atomized, and the atoms are retained within the tube (and the light path, which passes through the tube) for an extended period. As a result, sensitivity and detection limits are significantly improved.

Graphite furnace analysis times are longer than those for flame sampling, and fewer elements can be determined using GFAA. However, the enhanced sensitivity of GFAA and the ability of GFAA to analyze very small samples and directly analyze certain types of solid samples significantly expands the capabilities of atomic absorption.

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## WHAT IS ATOMIC EMISSION?

Atomic emission spectroscopy is a process in which the light emitted by excited atoms or ions is measured. The emission occurs when sufficient thermal or electrical energy is available to excite a free atom or ion to an unstable energy state. Light is emitted when the atom or ion returns to a more stable configuration or the ground state. The wavelengths of light emitted are specific to the elements which are present in the sample.

The basic instrument used for atomic emission is very similar to that used for atomic absorption with the difference that no primary light source is used for atomic emission. One of the more critical components for atomic emission instruments is the atomization source, because it must also provide sufficient energy to excite the atoms as well as atomize them.

The earliest energy sources for excitation were simple flames, but these often lacked sufficient thermal energy to be truly effective sources. Later, electrothermal sources such as arc/spark systems were used, particularly when analyzing solid samples. These sources are useful for doing qualitative and quantitative work with solid samples, but are expensive, difficult to use, and have limited applications.

Due to the limitations of the early sources, atomic emission initially did not enjoy the universal popularity of atomic absorption. This changed dramatically with the development of the Inductively Coupled Plasma (ICP) as a source for atomic emission. The ICP eliminates many of the problems associated with past emission sources and has caused a dramatic increase in the utility and use of emission spectroscopy.

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## WHAT IS THE ICP?

The ICP is an argon plasma maintained by the interaction of an RF field and ionized argon gas. The ICP is reported to reach temperatures as high as 10,000 °K, with the sample experiencing useful temperatures between 5,500 °K and 8,000 °K. These temperatures allow complete atomization of elements, minimizing chemical interference effects.

The plasma is formed by a tangential stream of argon gas flowing between two quartz tubes, as shown in Figure 2. Radio frequency (RF) power is applied through the coil, and an oscillating magnetic field is formed. The plasma is created when the argon is made conductive by exposing it to an electrical discharge which creates seed electrons and ions. Inside the induced magnetic field, the charged particles (electrons and ions) are forced to flow in a closed annular

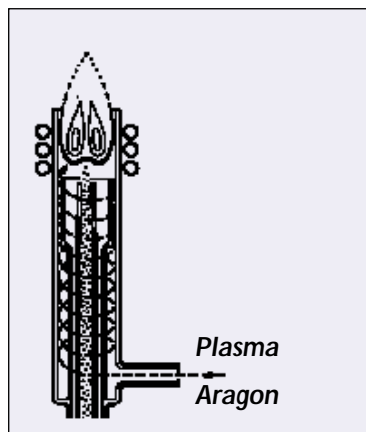


Figure 2. ICP torch assembly.

path. As they meet resistance to their flow, heating takes place and additional ionization occurs. The process occurs almost instantaneously, and the plasma expands to its full dimensions.

As viewed from the top, the plasma has a circular, “doughnut” shape. The sample is injected as an aerosol through the center of the doughnut. This characteristic of the ICP confines the sample to a narrow region and provides an optically thin emission source and a chemically inert atmosphere. This results in a wide dynamic range and minimal chemical interactions in an analysis. Argon is also used as a carrier gas for the sample.

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## WHAT IS ICP MASS SPECTROMETRY?

As its name implies, ICP Mass Spectrometry (ICP-MS) is the synergistic combination of an inductively coupled plasma with a quadrupole mass spectrometer. ICP-MS uses the ability of the argon ICP to efficiently generate singly charged ions from the elemental species within a sample. These ions are then directed into a quadrupole mass spectrometer.

The function of the mass spectrometer is similar to that of the monochromator in an AA or ICP emission system. However, rather than separating light according to its wavelength, the mass spectrometer separates the ions introduced from the ICP according to

their mass-to-charge ratio. Ions of the selected mass/charge are directed to a detector which quantitates the number of ions present. Due to the similarity of the sample introduction and data handling techniques, using an ICP-MS is very much like using an ICP emission spectrometer.

ICP-MS combines the multielement capabilities and broad linear working range of ICP emission with the exceptional detection limits of graphite furnace AA. It is also one of the few analytical techniques that permits the quantitation of elemental isotopic concentrations and ratios.

## HOW TO SELECT THE PROPER ATOMIC SPECTROSCOPY TECHNIQUE

With the availability of a variety of atomic spectroscopy techniques such as flame atomic absorption, graphite furnace atomic absorption, inductively coupled plasma emission, and ICP mass spectrometry, laboratory managers must decide which technique is best suited for the analytical problems of their laboratory. Because atomic spectroscopy techniques complement each other so well, it may not always be clear which technique is optimum for a particular laboratory. A clear understanding of the analytical problem in

the laboratory and the capabilities provided by the different techniques is necessary.

Important criteria for selecting an analytical technique include detection limits, analytical working range, sample throughput, cost, interferences, ease of use, and the availability of proven methodology. These criteria are discussed below for flame AA, graphite furnace AA (GFAA), ICP emission, and ICP mass spectrometry (ICP-MS).

## ATOMIC SPECTROSCOPY DETECTION LIMITS

The detection limits achievable for individual elements represent a significant criterion of the usefulness of an analytical technique for a given analytical problem. Without adequate detection limit capabilities, lengthy analyte concentration procedures may be required prior to analysis.

Typical detection limit ranges for the major atomic spectroscopy techniques are shown in Figure 3, and Table I (on page 5) provides a listing of detection limits by element for six atomic spectroscopic techniques: flame AA, hydride generation AA, graphite furnace AA (GFAA), ICP emission with radial and axial configurations, and ICP mass spectrometry.

Generally, the best detection limits are attained using ICP-MS or graphite furnace AA. For mercury and those elements that form hydrides, the cold vapor mercury or hydride generation techniques offer exceptional detection limits.

PerkinElmer defines its detection limits very conservatively with a 98% confidence level, based on established conventions for

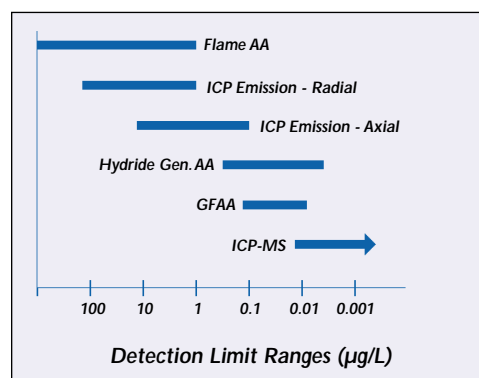


Figure 3. Typical detection limit ranges for the major atomic spectroscopy techniques.

the analytical technique. This means that if a concentration at the detection limit were measured many times, it could be distinguished from a zero or baseline reading in 98% (3 $\sigma$ ) of the determinations.

## ANALYTICAL WORKING RANGE

The analytical working range can be viewed as the concentration range over which quantitative results can be obtained without having to recalibrate the system. Selecting a technique with an analytical working range (and detection limits) based on the expected analyte concentrations minimizes analysis times by allowing samples with varying analyte concentrations to be analyzed together. A wide analytical working range also can reduce sample handling requirements, minimizing potential errors.

Figure 4 shows typical analytical working ranges with a single set of instrumental conditions.

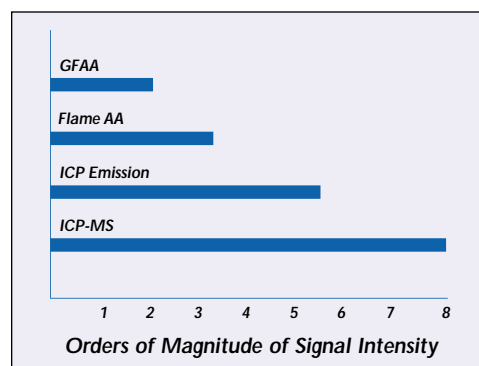


Figure 4. Analytical working ranges for the major atomic spectroscopy techniques.

Table I. Atomic Spectroscopy Detection Limits (micrograms/liter)

Elem	Flame AA	Hg/ Hydride	GFAA	ICP Emission	ICP-MS	Elem	Flame AA	Hg/ Hydride	GFAA	ICP Emission	ICP-MS
Ag	1.5		0.005	0.6	0.002	Mo	45		0.03	0.5	0.001
Al	45		0.1	1	0.005 <sup>a</sup>	Na	0.3		0.005	0.5	0.0003 <sup>c</sup>
As	150	0.03	0.05	2	0.0006 <sup>b</sup>	Nb	1500			1	0.0006
Au	9		0.15	1	0.0009	Nd	1500			2	0.0004
B	1000		20	1	0.003 <sup>c</sup>	Ni	6		0.07	0.5	0.0004 <sup>c</sup>
Ba	15		0.35	0.03	0.00002 <sup>d</sup>	Os				6	
Be	1.5		0.008	0.09	0.003	P	75000		130	4	0.1 <sup>a</sup>
Bi	30	0.03	0.05	1	0.0006	Pb	15		0.05	1	0.00004 <sup>d</sup>
Br					0.2	Pd	30		0.09	2	0.0005
C					0.8 <sup>e</sup>	Pr	7500			2	0.00009
Ca	1.5		0.01	0.05	0.0002 <sup>d</sup>	Pt	60		2.0	1	0.002
Cd	0.8		0.002	0.1	0.00009 <sup>d</sup>	Rb	3		0.03	5	0.0004
Ce				1.5	0.0002	Re	750			0.5	0.0003
Cl					12	Rh	6			5	0.0002
Co	9		0.15	0.2	0.0009	Ru	100		1.0	1	0.0002
Cr	3		0.004	0.2	0.0002 <sup>d</sup>	S				10	28 <sup>j</sup>
Cs	15				0.0003	Sb	45	0.15	0.05	2	0.0009
Cu	1.5		0.014	0.4	0.0002 <sup>c</sup>	Sc	30			0.1	0.004
Dy	50			0.5	0.0001 <sup>f</sup>	Se	100	0.03	0.05	4	0.0007 <sup>b</sup>
Er	60			0.5	0.0001	Si	90		1.0	10	0.03 <sup>a</sup>
Eu	30			0.2	0.00009	Sm	3000			2	0.0002
F					372	Sn	150		0.1	2	0.0005 <sup>a</sup>
Fe	5		0.06	0.1	0.0003 <sup>d</sup>	Sr	3		0.025	0.05	0.00002 <sup>d</sup>
Ga	75			1.5	0.0002	Ta	1500			1	0.0005
Gd	1800			0.9	0.0008 <sup>g</sup>	Tb	900			2	0.00004
Ge	300			1	0.001 <sup>h</sup>	Te	30	0.03	0.1	2	0.0008 <sup>k</sup>
Hf	300			0.5	0.0008	Th				2	0.0004
Hg	300	0.009	0.6	1	0.016 <sup>i</sup>	Ti	75		0.35	0.4	0.003 <sup>l</sup>
Ho	60			0.4	0.00006	Tl	15		0.1	2	0.0002
I					0.002	Tm	15			0.6	0.00006
In	30			1	0.0007	U	15000			10	0.0001
Ir	900		3.0	1	0.001	V	60		0.1	0.5	0.0005
K	3		0.005	1	0.0002 <sup>d</sup>	W	1500			1	0.005
La	3000			0.4	0.0009	Y	75			0.2	0.0002
Li	0.8		0.06	0.3	0.001 <sup>c</sup>	Yb	8			0.1	0.0002 <sup>m</sup>
Lu	1000			0.1	0.00005	Zn	1.5		0.02	0.2	0.0003 <sup>d</sup>
Mg	0.15		0.004	0.04	0.0003 <sup>c</sup>	Zr	450			0.5	0.0003
Mn	1.5		0.005	0.1	0.00007 <sup>d</sup>						

All detection limits are given in micrograms per liter and were determined using elemental standards in dilute aqueous solution. All detection limits are based on a 98% confidence level (3 standard deviations).

All atomic absorption (AAAnalyst™ 800) detection limits were determined using instrumental parameters optimized for the individual element, including the use of System 2 electrodeless discharge lamps where available.

All ICP emission (Optima 4300™) detection limits were obtained under simultaneous multielement conditions with the axial view of a dual-view plasma using a cyclonic spray chamber and a concentric nebulizer.

Cold vapor mercury detection limits were determined with a FIAS™-100 or FIAS-400 flow injection system with amalgamation accessory. The detection limit without an amalgamation accessory is 0.2 µg/L with a hollow cathode lamp, 0.05 µg/L with a System 2 electrodeless discharge lamp. (The Hg detection limit with the dedicated FIMS™-100 or FIMS-400 mercury analyzers is <0.005 µg/L without an amalgamation accessory and <0.0002 µg/L with an amalgamation accessory.) Hydride detection limits shown were determined using an MHS-15 Mercury/Hydride system.

Graphite furnace AA detection limits were determined on an AAAnalyst 800 using 50-µL sample volumes, an integrated platform and full STPF conditions. SIMAA™ 6000 detection limits are similar or slightly better depending upon the element and the mode of instrument operation. Graphite furnace detection limits can be further enhanced by the use of replicate injections.

Unless otherwise noted, ICP-MS detection limits were determined using an ELAN® 6100 equipped with Ryton® spray chamber, Type II Cross-Flow nebulizer, and nickel cones. All detection limits were determined using 3-second integration times and a minimum of 8 measurements. Letters following an ICP-MS detection limit value refer to the use of specialized conditions or a different model instrument as follows:

<sup>a</sup> Run on ELAN DRC™ in standard mode using Pt cones and quartz sample introduction system. <sup>b</sup> Run on ELAN DRC in DRC mode using Pt cones and quartz sample introduction system. <sup>c</sup> Run on ELAN DRC in standard mode in Class-100 Clean Room using Pt cones and quartz sample introduction system. <sup>d</sup> Run on ELAN DRC in DRC mode in Class-100 Clean Room using Pt cones and quartz sample introduction system. <sup>e</sup> Using C-13. <sup>f</sup> Using Dy-163. <sup>g</sup> Using Gd-157. <sup>h</sup> Using Ge-74. <sup>i</sup> Using Hg-202. <sup>j</sup> Using S-34. <sup>k</sup> Using Te-125. <sup>l</sup> Using Ti-49. <sup>m</sup> Using Yb-173.

## SAMPLE THROUGHPUT

**Sample throughput** is the number of samples which can be analyzed or elements which can be determined per unit time. For most techniques, analyses performed at the limits of detection or where the best precision is required will be more time-consuming than less demanding analyses. Where these factors are not limiting, however, the number of elements to be determined per sample and the analytical technique will determine the sample throughput.

**Flame AA** provides exceptional sample throughput when analyzing a large number of samples for a limited number of elements. A typical determination of a single element requires only 3–10 seconds. However, flame AA requires specific light sources and optical parameters for each element to be determined and may require different flame gases for different elements. In automated multielement flame AA systems, all samples normally are analyzed for one element, the system is then automatically adjusted for the next element, and so on. As a result, even though it is frequently used for multielement analysis, flame AA is generally considered to be a single-element technique.

**Graphite Furnace AA (GFAA).** As with flame AA, GFAA is basically a single-element technique. Because of the need to thermally program the system to remove solvent and matrix components prior to atomization, GFAA has a relatively low sample throughput. A typical graphite furnace determination normally requires 2–3 minutes.

**ICP emission** is a true multielement technique with exceptional sample throughput. ICP emission systems typically can determine 10–40 elements per minute in individual samples. Where only a few elements are to be determined, however, ICP is limited by the time required for equilibration of the plasma with each new sample, typically about 15–30 seconds.

**ICP-MS** is also a true multielement technique with the same advantages and limitations of ICP emission. The sample throughput for ICP-MS is typically 20–30 element determinations per minute depending on such factors as the concentration levels and required precision.

## COSTS

As they are less complex systems, instrumentation for single-element atomic spectroscopy (flame AA and GFAA) is generally less costly than that for the multielement techniques (ICP emission and ICP-MS). There can also be a considerable variation in cost among instrumentation for the same technique. Instruments offering only basic features are generally less expensive than more versatile systems, which frequently also offer a greater degree of automation. Figure 5 provides a comparison of typical cost ranges for the major atomic spectroscopy techniques.

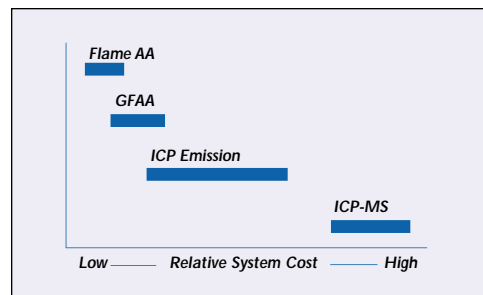


Figure 5. Typical relative system costs for atomic spectroscopy systems.

## INTERFERENCES

Few, if any, analytical techniques are free of interferences. With atomic spectroscopy techniques, however, most interferences have been studied and documented, and methods exist to correct or compensate for those interferences which may occur. A summary of

the types of interferences seen with atomic spectroscopy techniques, all of which are controllable, and the corresponding methods of compensation are shown in Table II (see next page).

*Table II. Atomic Spectroscopy Interferences*

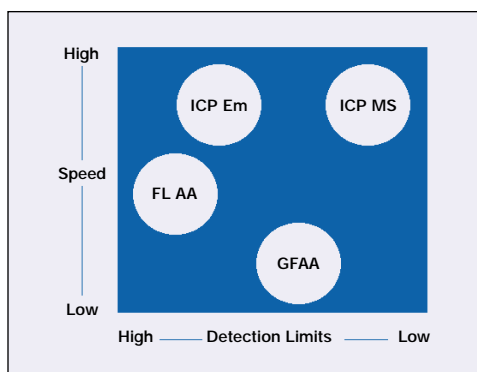
Technique	Type of Interference	Method of Compensation
<b>Flame AA</b>	Ionization	Ionization buffer
	Chemical	Releasing agent or nitrous oxide-acetylene flame
	Physical	Dilution, matrix matching, or method of additions
<b>GFAA</b>	Physical and chemical	STPF conditions
	Molecular absorption	Zeeman or continuum source background correction
	Spectral	Zeeman background correction
<b>ICP Emission</b>	Spectral	Background correction or the use of alternate analytical lines
	Matrix	Internal standardization
<b>ICP-MS</b>	Mass overlap	Interelement correction, use of Dynamic Reaction Cell™ (DRC™) technology, use of alternate mass values, or higher mass resolution
	Matrix	Internal standardization

## OTHER COMPARISON CRITERIA

Other comparison criteria for analytical techniques include the ease of use, required operator skill levels, and availability of documented methodology.

- **Flame AA** is very easy to use. Extensive applications information is available. Excellent precision makes it a preferred technique for the determination of major constituents and higher concentration analytes.
- **GFAA** applications are well-documented, though not as completely as with flame AA. GFAA has exceptional detection limit capabilities but with a limited analytical working range. Sample throughput is less than that of other atomic spectroscopy techniques. Operator skill requirements are somewhat more extensive than for flame AA.
- **ICP Emission** is the best overall multielement atomic spectroscopy technique, with excellent sample throughput and very wide analytical range. Good documentation is available for applications. Operator skill requirements are intermediate between flame AA and GFAA.
- **ICP-MS** is a technique with exceptional multielement capabilities at trace and ultratrace concentration levels and the ability to perform isotopic analyses. Good basic documentation for interferences exists. Applications documentation is well documented and continues to grow rapidly. ICP-MS requires operator skills similar to those for ICP emission and GFAA.

## COMPARISON SUMMARY



*Figure 6. A general selection guide for atomic spectroscopy instrumentation based on sample throughput and concentration range.*

The main selection criteria for atomic spectroscopy techniques—concentration range and analytical throughput—are summarized in Figure 6. Where the selection is based on analyte detection limits, flame AA and ICP emission are favored for moderate to high levels, while graphite furnace AA and ICP-MS are favored for lower levels. ICP emission and ICP-MS are multielement techniques, favored where large numbers of samples are to be analyzed.

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## WHY PerkinElmer ATOMIC SPECTROMETRY INSTRUMENTS?

### PerkinElmer Firsts

- Since 1960, when PerkinElmer introduced the first commercial double-beam atomic absorption instrument, PerkinElmer products have remained the standard to which all atomic absorption instrumentation is compared.
- PerkinElmer also introduced the first graphite furnace in 1970, and Zeeman-corrected graphite furnace analysis in 1981. PerkinElmer GFAA systems are being successfully used worldwide for the determination of ultratrace elements in a wide variety of samples.
- In 1980, PerkinElmer announced the first ICP emission/AA system. Today, thousands of PerkinElmer ICP emission systems are in operation.
- The PerkinElmer SCIEX ELAN® was the first commercially available ICP-MS system in 1984 and remains the standard in this newest atomic spectroscopy technique.
- For more than four decades, PerkinElmer has consistently been the leader in atomic spectroscopy. We stay out in front because of our responsive engineering and technology. Our commitment to you is a total one. We want to do everything possible to satisfy the users of our instruments because we are a full range analytical instrument company. We know we must satisfy your analytical needs with each of our products to maintain your continued business.

### Worldwide Customer Support

One way we satisfy users of our instrumentation is to offer them extensive customer support in addition to excellence in engineering and technical expertise. PerkinElmer supplies this support in numerous ways:

- **Technical Specialists.** PerkinElmer has regional atomic spectroscopy specialists located throughout the world, responsible for providing customer training, demonstrations, technical assistance and seminars to all users and prospective customers.
- **Literature.** The famous “Cookbook” is provided with all PerkinElmer AA instrument purchases. It contains information on AA conditions for the determination of 72 individual elements and over 400 analyses. A similar manual is provided with each graphite furnace. PerkinElmer also offers an array of published articles, application notes, and other technical literature on atomic spectroscopy (see Section 2).
- **Customer Training Courses.** PerkinElmer offers customer training courses for flame AA, furnace AA, ICP emission, and ICP-MS on a regional basis at sites around the world.
- **Service and Support.** PerkinElmer maintains service and support offices throughout the world, staffed by service engineers who have received extensive factory training in atomic spectroscopy.

**For information on the above and more,** contact your local PerkinElmer sales representative or PerkinElmer Instruments LLC, 761 Main Avenue, Norwalk, CT, 06859-0010 U.S.A. via the attached business reply card, e-mail at: [info@perkin-elmer.com](mailto:info@perkin-elmer.com), Tel: (+1) 203-762-4000 or 800-762-4000, Fax: (+1) 203-762-4228, visit the PerkinElmer website at: [www.perkinelmer.com](http://www.perkinelmer.com)



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The articles are arranged by analytical technique and subdivided by field of interest (i.e., agriculture, biochemistry) and general information. Most of the work described was done with PerkinElmer atomic spectroscopy instruments. Laboratories equipped with such instruments may expect similar performance. However, due to important differences among optics and electronics, one cannot be certain that all of these analyses can be repeated with other instruments.

Many of the articles listed were published in *Atomic Spectroscopy*, a bi-monthly journal on analytical atomic spectroscopy. A moderate charge is made for subscriptions. A free one-year subscription is furnished with the purchase of a PerkinElmer AA, ICP, or ICP-MS. For a free copy of the journal or to publish an applications article, contact editor at e-mail: [lustan@perkin-elmer.com](mailto:lustan@perkin-elmer.com)

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**ATOMIC ABSORPTION:  
TOXICOLOGIC, CLINICAL,  
AND FORENSIC**

**AA-1248** M. Feuerstein and G. Schlemmer, **Determination of Se in Human Serum by GFAAS With Transversely Heated Graphite Atomizer and Longitudinal Zeema-Effect Background Correction**, *At. Spectrosc.* 20(5), 180-185 (1999).

**AA-1245** T. Guo, J. Baasner and D.L. Tsalev, **Fast Automated Determination of Toxicologically Relevant Arsenic in Urine by Flowing Hydride Penetration AAS**, PerkinElmer Bodenseewerk (1998).

**AA-1238** T. Guo and J. Baasner, **Technical Note: Determination of Mercury in Blood by On-line Digestion with FIMS**, *Automatic Chem.* 18(6), 217 (1996).

**AA-1236** C.L. Wabner and D.C. Sears, **Determination of Urinary Ca, Mg and Li Using FI With Flame AAS**, *At. Spectrosc.* 17(3), 119 (1996).

**AS-1226** C.L. Wabner and D.C. Sears, **Determination of Urinary Ca, Mg, and Li Using Flow Injection with Flame AAS**, *At. Spectrosc.* 17(3), 119 (1996).

**AS-1223** T. Guo, J. Baasner, M. Gradl, and A. Kistner, **Determination of Mercury in Saliva with a Flow Injection System**, *Anal. Chim. Acta* 320, 171 (1996).

**AS-1188** C.P. Bosnak, D. Bradshaw, R. Hergenreder, and K. Kingston, **Graphite Furnace Analysis of Pb in Blood Using Continuum Source Background Correction**, *At. Spectrosc.* 14, 80 (1993).

**AS-1184** C.P. Hanna, J.F. Tyson, and S. McIntosh, **Determination of Inorganic**

**Arsenic and its Organic Metabolites in Urine by Flow-Injection Hydride Generation Atomic Absorption Spectrometry**, *Clin. Chem.* 39, 1662 (1993).

**AS-1182** P.J. Parsons, **A Rapid Zeeman Graphite Furnace Atomic Absorption Spectrometric Method for the Determination of Lead in Blood**, *Spectrochim. Acta* 48B, 925 (1993).

**AS-1178** I. Shuttler, **The Application of a Transversely Heated Electrothermal Atomizer with Longitudinal Zeeman-Effect Background Correction to the Determination of Vanadium in Urine**, *At. Spectrosc.* 13(5), 174 (1992).

**AS-1116** A. J. Schermaier, L. H. O'Connor, and K. H. Pearson, **Semi-automated Determination of Chromium in Whole Blood and Serum by Zeeman Electrothermal Atomic Absorption Spectrophotometry**, *Clin. Chim. Acta.* 152, 123 (1985).

**AS-1110** B. Welz and G. Schlemmer, **Determination of Arsenic, Selenium and Cadmium in Marine Biological Tissue Samples Using a Stabilized Temperature Platform Furnace and Comparing Deuterium Arc with Zeeman-effect Background Correction Atomic Absorption Spectrometry**, *J. Anal. At. Spectrom.* 1, 119 (1986).

**AS-1042** F. Y. Leung and A. R. Henderson, **Determination of Aluminum in Serum and Urine Using Matrix Modification and the L'vov Platform**, *At. Spectrosc.* 4, 1 (1983).

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**ATOMIC ABSORPTION:  
ENVIRONMENTAL**

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SPECIATION**

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## SECTION 3

### PerkinElmer Atomic Spectroscopy Instrumentation

**AA**  
**GFAA**  
**ICP**  
**ICP-MS**

PerkinElmer offers a complete line of atomic spectroscopy instrumentation designed to suit any analytical laboratory needs and budget. The following section provides a broad overview of PerkinElmer systems, techniques, and accessories. For more detailed information contact your local PerkinElmer representative, or fill out and mail/fax the attached business reply card, visit our website at: [www.perkinelmer.com](http://www.perkinelmer.com), email us at: [info@perkin-elmer.com](mailto:info@perkin-elmer.com), Tel: (+1) 203-762-4000 or 800-762-4000, or Fax (+1) 203-762-4228.



*AAAnalyst 100 Atomic Absorption Spectrometer*

## ATOMIC ABSORPTION: FLAME / FURNACE

The **AAAnalyst™ 100** is a double-beam spectrometer with built-in keyboard control, a single lamp mount, automated wavelength and slit selection. The AAAnalyst 100 includes a high light-throughput, double-beam optical system with a dual-blazed grating monochromator for optimized performance over the entire AA wavelength range. Front-surfaced reflecting optics with protective coatings for improved UV reflectivity and corrosion resistance are used throughout. The optical system is fully protected using covers with a unique system of tongue and groove closures for further protection against dust and corrosive atmospheres.

The AAAnalyst 100 AA spectrometer is available in three configurations: **(a)** without background corrector and motorized lamp turret, **(b)** with background corrector only, or **(c)** with both background corrector and motorized lamp turret. Three additional configurations are available without a burner system for dedicated use with graphite furnace (AA WinLab required) or hydride or Hg determinations. These determinations are **(a)** with background and without a motorized lamp turret, **(b)** without background correction and with a motorized lamp turret, and **(c)** with background correction and a motorized lamp turret.

All parameters, except burner adjustments and gas flows, are controlled via a built-in keyboard and two-line alphanumeric vacuum fluorescent display which prompts the user through system setup for flame and furnace determinations and displays analytical results and error conditions. Method storage

is included for flame, furnace, and flow injection methods. The AAAnalyst 100 can also directly access and select the stored methods in the FIAS™-100 and FIAS™-400 Flow Injection Systems.

The AAAnalyst 100 provides readings in emission intensity, absorbance, or concentration. A built-in parallel printer connection is provided for recording analytical results, calibration curves, and peak profiles.

The AAAnalyst 100 uses the PerkinElmer premix burner system. The burner system includes a high-strength mixing chamber for chemical resistance, an adjustable high-precision nebulizer, and an all-titanium 10-cm air-acetylene burner head. Various optional nebulizers provide for maximum flexibility, permitting the analysis of a wide variety of sample matrices. The entire burner assembly is made for quick removal using the quick disconnect mounting system.

The AAAnalyst 100 gas controls include flow control for air, nitrous oxide, and acetylene and automatic flame ignition. Automatic sequencing of gases when lighting or extinguishing a nitrous oxide-acetylene flame (even in the event of power failure) is provided, as are burner head, nebulizer/end cap, flame sensing, fuel and oxidant pressure sensing, flame shield temperature, liquid level in drain vessel and a burner drain interlock. Purging of the gas box is controlled through the keyboard. The AAAnalyst 100 also includes a single lamp mount, operating instructions, and selected spare parts.



*AAAnalyst 300 Atomic Absorption Spectrometer*

## **ATOMIC ABSORPTION: FLAME / FURNACE**

**The AAAnalyst™ 300** is designed for cost-effective, automatic flame, graphite furnace, FIAS, and mercury/hydride analyses. Standard features include complete system control from a single keyboard, a motor-driven 6-lamp turret for fully automatic multielement analyses, built-in deuterium arc background corrector, and the PerkinElmer burner with automatic, computer-programmed flame gas control.

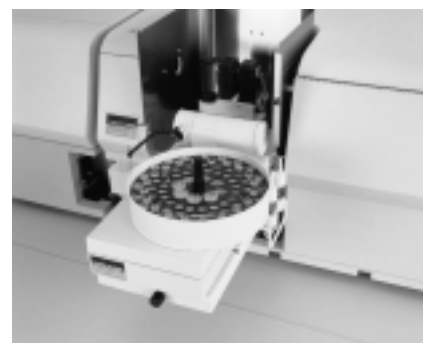
- The AAAnalyst 300 includes a high light throughput, double-beam optical system with a dual-blazed grating monochromator for optimized performance over the entire AA wavelength range. Front-surfaced, reflecting optics with protective coatings for improved UV reflectivity and corrosion resistance are used throughout. The optical system is fully protected using covers with a unique system of tongue and groove closures for further protection against dust and corrosive atmospheres.
- Full control of the spectrometer and optional accessories such as Flow Injection Systems, Flame/FIAS Autosamplers, HGA®-850 Graphite Furnace and Furnace Autosampler is via an industry-standard personal computer (PC) using PerkinElmer AA WinLab software running under the Microsoft Windows operating

environment. The computer provides single keyboard control of wavelength, slit width, and gas flows. When used with PerkinElmer Lumina™ hollow cathode lamps, the AAAnalyst 300 will automatically align the lamp and set lamp current, wavelength, and slit settings.

- The AAAnalyst 300 uses the PerkinElmer premix burner system, which includes a high-strength mixing chamber for chemical resistance, an adjustable high-precision nebulizer, and an all-titanium 10-cm air-acetylene burner head. Various optional nebulizers provide for maximum flexibility permitting the analysis of a wide variety of sample matrices.
- The entire burner assembly is made for quick removal using the quick disconnect mounting system. Automatic sequencing of gases when lighting or extinguishing a nitrous-oxide-acetylene flame (even in the event of a power failure) is provided, as are burner head, nebulizer/end cap, flame sensing, fuel and oxidant pressure sensing, flame shield temperature sensing, liquid level in drain vessel sensing, and a burner drain interlock.
- The AAAnalyst 300 and its accessories are fully computer-controlled using the powerful AA WinLab™ software. AA WinLab offers unmatched versatility and simplicity, GLP and GALP compliance and built-in diagnostics for performance verification. With AA WinLab data can be transferred to other Windows-based software providing advanced, customized report generation capabilities. Single-element and multi-element method files and analytical data files may be stored for later recall and use. Files may also be stored on floppy disks for archival or back-up purposes. Graphic data may also be stored and recalled for later manipulation, including replot, scaling,

and factoring. The AA WinLab software also includes an on-line, context-sensitive help mode as well as automatic quality control features such as check samples with user-specified tolerance ranges and courses of action if the results are outside the allowable ranges. AA WinLab software allows data files to be transferred to other Windows-based software providing advanced, customized report generation capabilities. Both alphanumeric and graphic data may be printed with an optional printer, which is required but not supplied, for hard copy printout.

## **HGA-850 Graphite Furnace for the AAAnalyst 300 AAS**



**The HGA®-850 graphite furnace** is the latest in advanced furnace designs which provides unparalleled performance, flexibility, ease-of-use, and advanced regulatory compliance for use with the AAAnalyst 300 atomic absorption spectrometer. It is fully computer-controlled, offers the best possible detection limits down to the pg range, sample consumption as low as a few µL, highest freedom from interferences, and proven reliability.



*AAAnalyst 600/700/800 Atomic Absorption Spectrometers*

## ATOMIC ABSORPTION: FLAME / FURNACE

**The AAAnalyst™ 600, 700, and 800 AAS** are highly integrated, high-performance atomic absorption spectrometers.

The **AAAnalyst 600** is equipped with a top-of-the-line transversely-heated THGA™ graphite furnace AA with longitudinal Zeeman-effect background correction.

The **AAAnalyst 700** is equipped with high-performance flame AA and classic HGA® graphite furnace AA with deuterium background correction.

The **AAAnalyst 800** uses the same furnace as the AAAnalyst 600, but also includes a high-performance flame AA.

For the first time in AA history, the burner system for flame AA, the graphite furnace (HGA or THGA), either deuterium or Zeeman-effect background correction, and even power supplies for hollow cathode lamps (HCLs) and electrodeless discharge lamps (EDLs) are integrated in one instrument housing. In addition, the AAAnalyst 700 and 800 include automated motorized flame-furnace atomizer exchange, offering the full dynamic range and versatility of AA—percent to picograms—under software control.

The AAAnalyst 600, 700, and 800 instruments feature high-performance optics with a customized solid-state detector from Hamamatsu Photonics K.K., the world leader in photo detection technology. The detector is optimized for high UV quantum efficiency, and is more efficient over the entire wavelength range than a conventional photomultiplier. This optical system provides the AAAnalyst 600, 700 and 800 with maximum light throughput and exceptional signal-to-noise ratios. That translates directly into improved detection limits and precision.

The AAAnalyst 600, 700 and 800 use state-of-the-art enhanced power control circuitry to provide a furnace atomization heating rate greater than 2000 °C that is independent over a wide range of input line voltages (190-250V). The result is the highest degree of free-

dom from interferences and the most reproducible characteristic mass values of any furnace available—winter and summer, anytime.

The high-performance flame AA of the AAAnalyst 700 and 800 contains a wide variety of performance, safety and ease of use features including automated burner position optimization and full safety interlocks. The TotalFlow™ gas control system maintains gas flows at set levels even when subjected to outside variations, such as nebulizer adjustment providing exceptional stability and performance.

The AAAnalyst 600, 700, and 800 and their accessories are fully computer-controlled using the powerful AA WinLab™ software. AA WinLab offers unmatched versatility and simplicity, GLP and GALP compliance and built-in diagnostics for performance verification. With AA WinLab data can be transferred to other Windows®-based software providing advanced, customized report generation capabilities.

The **AS-800 Autosampler** is a computer-controlled high-precision system that is standard with the AAAnalyst 600, 700 and 800. This autosampler can accommodate up to 148 samples, standards or modifiers with true random sampling. Digital, micro-stepper motor-driven pipette motors provide unmatched accuracy and reproducibility.



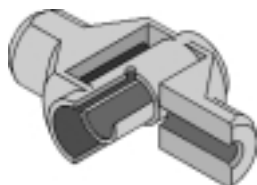
*SIMAA 6000 Simultaneous Multi-Element Graphite Furnace AA Spectrometer*

#### **ATOMIC ABSORPTION: GRAPHITE FURNACE**

**The SIMAA™ 6000 AAS** is a totally automated simultaneous multi-element analysis system for graphite furnace atomic absorption. The SIMAA 6000 is a compact benchtop AA instrument, including all spectrometer and furnace components in a single unit for minimum space requirements. Full control of the spectrometer, graphite furnace, autosampler and other accessories is via an industry standard personal computer (PC) using PerkinElmer AA WinLab™ software running under the Microsoft® Windows® operating environment.

- **The SIMAA 6000** incorporates the unique PerkinElmer Tetrahedral Echelle Polychromator (TEP) optical system for simultaneous multi-element analysis. Wavelength range is from 190-860 nm on a two-dimensional focal plane. Scanning operation is available for automatic access of any wavelength on the focal plane. The detector is a custom-made monolithic solid-state type with 61 high-performance photodiodes allowing for the simultaneous determination of up to six elements. Built-in lamp power supplies are available for both the PerkinElmer hollow cathode lamps and the PerkinElmer System 2 electrodeless discharge lamps.
- **Zeeman-effect background correction** provides the exceptional correction accuracy required with ultratrace GFAA analyses. The use of a longitudinal "AC" Zeeman system further enhances system performance by eliminating the need for a polarizer or other energy-reducing components in the optical system.
- **A Transversely Heated Graphite Atomizer (THGA™)** with an integrated L'vov platform is an integral part of the SIMAA 6000. This advanced furnace design provides a uniform temperature over the entire graphite tube length to minimize temperature gradients and condensation effects. With the THGA, all graphite furnace elements can be determined using the L'vov platform and other key components of the Stabilized Temperature Graphite Furnace (STPF) technology that provides nearly interference-free GFAA analysis.
- **An 80-position AS-72 Furnace Autosampler** is standard equipment with the SIMAA 6000. All autosampler parameters are set and controlled via the system computer and software.

## GRAPHITE FURNACE ATOMIC ABSORPTION SYSTEMS



Transversely heated graphite tube with integrated L'vov platform.

**Graphite furnace atomic absorption (GFAA)** allows the determination of over 40 elements in microliter sample volumes with detection limits typically 100 to 1000 times better than those of flame atomic absorption. PerkinElmer has been acknowledged as the leader in GFAA since it introduced the first commercially available graphite tube furnace in 1970.

**Optimum performance with GFAA** requires more than merely replacing a burner system with a graphite furnace. The spectrometer must be optimally designed to meet the special requirements of the furnace. The optical system must provide maximum light throughput without viewing the incandescent inner surfaces of the heated furnace. Instrument electronics must be able to respond accurately to the fast, transient signals generated with furnace sampling and to correct for minor variations in the baseline signal. Background correction systems must be able to accurately compensate for the higher and more complex background absorption seen with many sample types in the furnace.

The furnace must also be designed to provide optimum analytical conditions. The sample must be atomized into a controlled, thermally stable environment to prevent potential interferences and analytical error.

### • Transversely Heated Graphite Tube (THGA): L'vov Platform

The preferred means of achieving a thermally stable environment is through the use of transversely applied maximum power heating and a device known as the L'vov platform. The function of the platform is to delay the vaporization and atomization of the sample until the furnace atmosphere has reached equilibrium conditions.

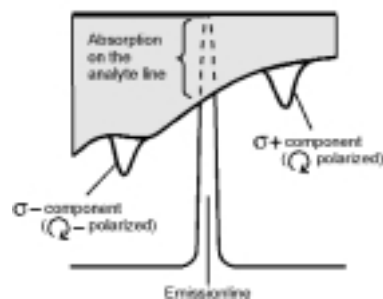
In addition to the above requirements, all graphite components of the furnace must be inert, long-lived, and of consistently high quality to ensure long-term reproducibility.

### • STPF Concept

PerkinElmer has included these features and more in its THGA™ and HGA® graphite furnace systems. Using an advanced concept called the Stabilized Temperature Platform Furnace (STPF), PerkinElmer GFAA systems provide nearly interference-free analyses.

PerkinElmer AA spectrometers with Zeeman-effect background correction, combined with PerkinElmer STPF graphite furnaces represent the state of the art in graphite furnace atomic absorption analysis.

## BACKGROUND CORRECTION FOR FLAME AND GRAPHITE FURNACE AA



Longitudinal Zeeman-effect background correction.

• **Continuum source background correction** can accurately compensate for almost all background problems encountered with flame AA. It is also adequate for many of the background problems encountered with graphite furnace AA (GFAA). However, GFAA can generate higher levels and more spectrally complex background absorption than is seen with flame AA. In those instances, Zeeman-effect background correction is the preferred compensation technique.

• **Zeeman-effect background correction** can be used at very high background absorption levels, can accurately correct for structured background in most cases, and can even eliminate some types of spectral interferences encountered when using a continuum source background correction system. In addition, Zeeman-effect background correction provides true double-beam operation while using only a single, time-shared light path.

Zeeman-effect background correction takes advantage of the fact that the absorption profile for an element splits into several components in the presence of a

strong magnetic field. For most elements, the central (pi) component occurs at the absorption wavelength for the element. The outlying components (called sigma components) are usually sufficiently separated from the pi component that little or no atomic absorption occurs at these wavelengths.

• **In state-of-the-art longitudinal "AC" Zeeman systems**, the graphite furnace is positioned longitudinally relative to the magnetic field. The combined atomic and background absorption is measured while the magnetic field is off. The detector sees only the background absorption when the magnetic field is on as the pi component is not detected. The difference between the two signals is the corrected atomic absorption signal. The major advantages of the longitudinal "AC" Zeeman system are that it measures background absorption at exactly the wavelength that it measures atomic absorption and it does not require the use of a polarizer to eliminate the pi component, thereby providing higher light throughput and improved analytical performance.

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## GRAPHITE FURNACE AUTOSAMPLERS FOR AA

**PerkinElmer graphite furnace autosamplers** offer two distinct advantages over manual sample introduction: **automation and improved performance**. A complete set of samples and standards can be run totally unattended. When used with today's advanced AA spectrometers, furnace autosamplers can prepare working standards from a concentrated stock standard, add the

proper amounts of matrix modifiers to both samples and standards, and even perform analyses using the method of additions—all automatically and totally under the operator's control. In addition to the obvious advantages of automation, furnace autosamplers also guarantee accurate, reproducible sample introduction into the furnace for the best possible analytical results.

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## THE DUAL OPTION BURNER SYSTEM FOR AA

The burner system is the heart of any atomic absorption spectrometer. The performance and durability of PerkinElmer's **Dual Option Burner System**, which is supplied with all PerkinElmer atomic absorption instruments, have been proven in thousands of laboratories worldwide.

The Dual Option Burner System is constructed of high strength, corrosion-resistant materials to provide safe operation and durability. For optimum performance, three gas flows are used. The primary oxidant flow is directed through the nebulizer and is fixed to ensure a constant sample uptake rate and optimum precision. A separate auxiliary oxidant flow is used to vary the total oxidant for optimized performance with all sample and flame types. Fuel flow is also separately controlled, and fuel and oxidant are mixed inter-

nally in the burner chamber for maximum safety. Burner heads supplied with the Dual Option Burner System are made entirely of titanium for maximum corrosion resistance and optimum heat dissipation.

PerkinElmer AA instruments include a high-precision nebulizer. Various optional nebulizers provide for maximum flexibility permitting the analysis of a wide variety of sample matrices. An optional high-sensitivity nebulizer is available for those applications requiring the utmost in sensitivity and detection limits. All PerkinElmer AA nebulizers are adjustable, so that all types of sample matrices—aqueous or organic, acids or bases, dilute or concentrated—can be analyzed under optimum conditions with maximum signal stability and minimal carryover.

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## LUMINA HOLLOW CATHODE LAMPS (HCL) AND ELECTRODELESS DISCHARGE LAMPS (EDL) FOR AA INSTRUMENTS

**PerkinElmer Lumina™ hollow cathode lamps** for single-element and multielement determinations, come in two series: coded, cableless, and coded with cable. The coded, cableless series is designed for use with PerkinElmer's AAnalyst Models 100/300/600/700/800 of instruments. The coded with cable series includes a cable that allows Lumina lamps to be recognized by the following instruments: Models SIMAA 6000, 5100, 5100 PC, 4110 ZL, 4100, 4100 ZL, 3300, 2100, and 1100(B). With the appropriate adapter cable, Lumina hollow cathode lamps can also be used with all earlier PerkinElmer AA spectrometers which do not have the automatic code reading capability.

Where greater intensity is required for improved analytical performance, **PerkinElmer's EDL System 2** provides 5 to 20 times the intensity of conventional hollow cathode lamps. PerkinElmer System 2 EDLs also offer greater spectral purity for many elements for enhanced sensitivity and extended linear working ranges. They are also exceptionally long-lived. System 2 EDLs fit all PerkinElmer lamp mounts and turrets. Because EDLs have different power requirements than HCLs, an accessory power supply is required to use EDLs with most instruments. (A System 2 EDL Power Supply is built into the AAnalyst 600, AAnalyst 700, AAnalyst 800, SIMAA 6000 and 4110 ZL spectrometers.)

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## AUTOPREP 50 AUTOMATIC DILUTION SYSTEM

**The AutoPrep 50** permits truly automated flame atomic absorption spectroscopy. With automatic intelligent on-line dilution capabilities, the AutoPrep 50 increases laboratory productivity by eliminating the time-consuming task of manual sample dilution. The AutoPrep 50 offers fully automatic sample

introduction with automatic intelligent selection of dilution ranges. The AutoPrep 50 also automatically prepares multiple standards from a single stock solution and is fully controlled with AA WinLab software.



*Optima 4000 DV SCD Series ICP*

## ICP EMISSION

With the introduction of these new Optima™ ICP systems and software, PerkinElmer has completely redefined the ICP marketplace. You can get all of the benefits of solid-state detector systems in either a scanning CCD system or in an SCD system.

### **Optima 4000 DV SCD Series**

Only the Optima 4000™ DV Series of ICP systems has the optimized design essential to ensuring accuracy, improving method development, and consistently delivering the correct answer.

The Optima 4300™ DV ICP-OES offers the performance required to maximize productivity. While other simultaneous ICPs claim "speed," only the Optima 4000 has the optimized design required to ensure accuracy, improve method development, and consistently deliver the correct answer. The system is ideal for laboratories with moderate to heavy loads of difficult samples.

- **Improved productivity**

The Optima 4000 DV series significantly increases sample throughput. It can measure over 73 elements in seconds and run more samples per hour at a lower cost per analysis than any other system. Sample throughput is maximized in all areas of the instrument from the sample introduction system to the unique automated sample introduction modes. The software offers specific productivity tools; such as SmartRinse™, which customizes rinse times based on element concentrations in each sample.

- **Safe, stable, robust plasma**

The revolutionary, patented Optima 4000 solid-state RF power supply provides exceptional ruggedness and reliability. In addition, the solid-state design creates an exceptionally compact power supply to preserve valuable bench space. Free-running 40 MHz operation allows automatic optimization with all sample matrices and solvents.

- **Solid and dependable**

The Optima 4000 shatters the myth that state-of-the-art instruments require dedicated climate-controlled laboratories and a lot of pampering. The optical system is enclosed in a temperature-controlled housing, ensuring excellent performance in a normal laboratory environment. The system has no moving parts and requires minimal maintenance. Plus, the unique optical compartment ensures exceptional long- and short-term wavelength stability for greater accuracy, more repeatable results and improved productivity with less time spent on routine system calibration.

- **SCD means high performance**

The exclusive, patented high-performance, Segmented-array Charge-coupled Device (SCD) detector, provides unparalleled performance required for complex matrices, including ultratrace and multi-element samples. With over 2,500 systems installed, the Optima solid-state detector has the wavelength flexibility to successfully complete thousands of applications, ranging from drinking water to precious metals

and everything in between. Additionally, the Optima 4000 offers the industry's only five-year detector warranty. The system is available in multiple configurations to meet your needs. For example, the Optima 4300 model is the only ICP system designed with two solid-state detectors to maximize light throughput and resolution at all wavelengths.

- **Easy access, easy to use**

The large, easily accessible sample compartment is environmentally controlled to ensure fast equilibration, maximum sampling system stability and superior performance. The torch includes a true no-tools-required, quick-change mount. Anyone can perform routine torch maintenance, change sample introduction systems, and be back analyzing samples in minutes.

- **Lowest detection limits, broadest working range**

Method-controlled dual-viewing of the plasma allows the widest working range possible. Axial viewing allows trace measurements because it provides a longer emission path for increased sensitivity and lower background levels. At the same time, radial viewing permits percentage concentration measurements. The Optima 4300 offers the lowest detection limits and the greatest concentration range in a single system. You can even determine ultratrace and percentage concentration levels in your samples in the same run, automatically, without the time-consuming hunt for alternative wavelengths.



*Optima 2000 DV Scanning CCD ICP*

## ICP EMISSION

The Optima 2000 DV Scanning CCD is the newest member of the industry's most successful family of ICP instruments. Another PerkinElmer innovation, where scanning CCD technology results in highest performance and flexibility.

### Optima 2000 Scanning CCD

The new Optima 2000™ Scanning Charge-Coupled Device (CCD) ICP system brings advanced technology to the entry-level ICP market. The Scanning CCD detector collects a complete simultaneous analyte spectrum at speeds that far exceed conventional sequential systems. Automatic dual-viewing ensures the lowest detection limits and the widest working ranges. The Optima 2000 is the ideal solution for research and quality assurance laboratories that have a wide variety of samples and lower frequency of analysis.

The custom-designed solid-state detector, solid-state RF power supply and sealed optical system provide both superior performance and enhanced reliability. That reduces operating costs and, more importantly, ensures that the instrument is available when needed. Computer-controlled gas flows and mass-flow control of the nebulizer gas ensure day-to-day reproducibility.

The Optima's proven 32-bit Windows® software, WinLab32™, makes it easy to get up and running in minutes rather than days. Customizable method development enables analysts to quickly configure the sys-

tem, increasing lab productivity. The compact, benchtop design conserves valuable laboratory space.

- **Rugged, reliable power**

The Optima 2000 features a true solid-state, RF power supply to provide exceptional ruggedness and reliability, eliminating the need for power tubes. Solid-state design makes the power supply exceptionally compact.

- **Widest working range**

Method-controlled dual-viewing of the plasma delivers the widest working range possible, giving the lowest detection limits and the greatest concentration range in a single system. Axial viewing allows trace measurements because it provides a longer emission path for increased sensitivity and lower background levels. At the same time, radial viewing permits percentage concentration measurements. With the Optima 2000, trace and percentage concentration levels can be automatically determined in the same run without having to search for unfamiliar alternative wavelengths.

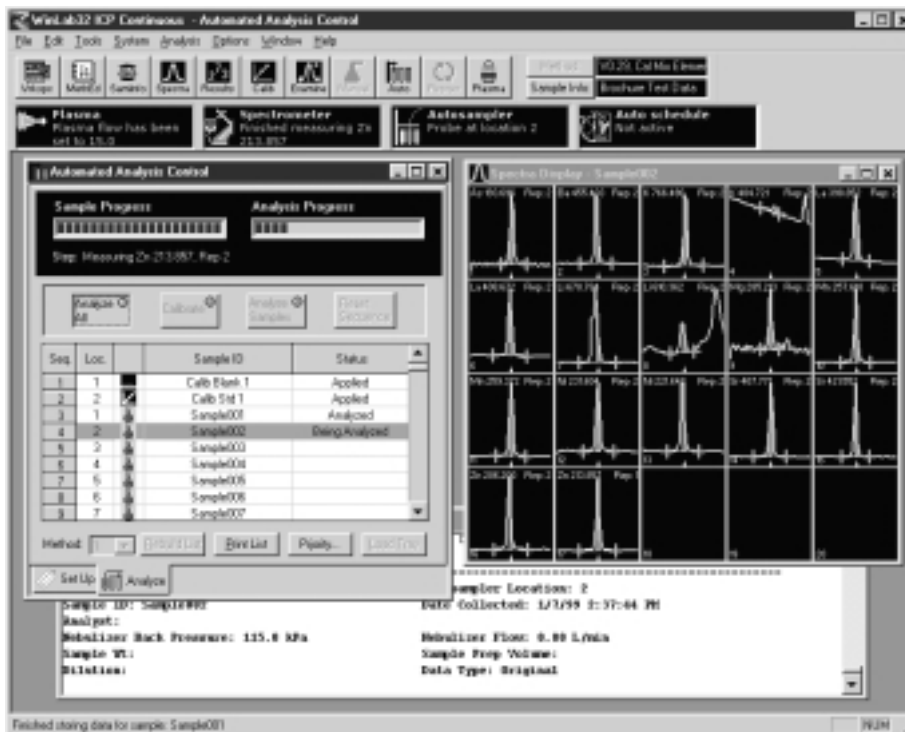
- **Shear gas advantage**

To eliminate interferences caused by the cooler regions in the plasma gas, the Optima 2000 uses a unique compressed air shear gas system to remove the cool tailplume of the plasma. This provides a maintenance-free, reliable system compared to alternative methods, which use expensive argon gas and water cooling and are prone to clogging

- **Accurate and reliable**

The Optima 2000 features a high-speed, high-resolution double monochromator and solid-state detector. High resolution yields reduced interferences and improved accuracy. Limited component movement and Dynamic Wavelength Stabilization ensure exceptional wavelength accuracy and reliability. With the optical system's superior light throughput and the unmatched quantum efficiency of the solid-state detector, the Optima 2000 gives you exceptional detection limits quickly and routinely.

- **Dynamic wavelength stabilization.** Since the system continually references a neon background, the Optima 2000 is faster, more precise and stable than conventional systems that rely on mercury references between reads. Dynamic Wavelength Stabilization (DWS) allows direct on-peak measurement, eliminating the need for peak searches.



A typical WinLab32 layout. The analyst determines what is displayed.

## WINLAB32 SOFTWARE FOR THE OPTIMA SERIES OF ICP INSTRUMENTS

### Intuitive and flexible control boosts productivity

Full-featured WinLab32™ software is easy to learn and easy to use, yet provides unmatched features and flexibility, controlling the entire family of Optima ICPs. Operating under powerful Microsoft® Windows NT®, WinLab32 has all the tools needed to analyze samples, report and archive data, and ensure regulatory compliance. Unlike other software applications that look easy at first but lack depth; WinLab32 combines practical functionality with advanced capability, ensuring that the software meets your customer's needs now and in the future.

- **Tools for optimum performance**

The unique optical system of the Optima 2000 and its exceptional stability allow WinLab32 to include tools previously available only in high-end simultaneous ICP-OES instruments. Features such as simultaneous background correction, inter-element correction (IEC) and multi-component spectral fitting (MSF) significantly enhance analytical performance and minimize potential interferences.

- **Confidence in your analysis**

Built-in diagnostics check each system component to verify proper operation. Windows NT is an exceptionally secure operating environment, and WinLab32 has

added even more security features, including password-controlled access to software functions.

- **Regulatory compliance**

Whether the regulations are internal or industry- or government-imposed, WinLab32 gives you the tools you need. Built-in compliance features include multiple user-defined quality control (QC) standards, check samples and a selection of calibration procedures.

- **Reporting made easy**

The WinLab32 report function uses Wizards to guide your customer through the process step-by-step. With WinLab32 multi-tasking capabilities, your customer can even generate reports while the Optima analyzes the next group of samples. WinLab32 stores all raw analytical data, so previously stored data can be reprocessed with new conditions, eliminating time-consuming process of repeating analyses.

- **Seamless data transfer**

WinLab32 can automatically reformat results for transfer to different programs or computers. Simply select the data and samples and specify the file format. WinLab32 can automatically generate a file configured for exporting directly into most spreadsheet, database and word processing programs. Save the file to disk or send it to any connected device.



ELAN 6100 ICP-MS and ELAN DRC ICP-MS

## ICP MASS SPECTROMETRY

### ELAN 6100 ICP-MS

The ELAN<sup>®</sup> 6100 ICP-MS simplifies ICP-MS by providing an easy-to-use, easy-to-maintain tool for routine ultra-trace level analysis. The proven design of the ELAN 6100 ensures accuracy, improves method development and consistently delivers the correct answer, reducing rework and improving productivity. The ELAN 6100 is ideal for environmental, clinical, geochemical and general testing laboratories with moderate to heavy loads of ultra-trace level samples. The ELAN 6100 offers the following advantages:

- **Superior detection limits**  
The ELAN 6100 performs analyses at the parts-per-trillion level and lower.
- **The industry's only single ion lens** makes changing the exclusive SwiftMount<sup>™</sup> ion lens as easy as changing a light bulb. The lens is also inexpensive, making replacement an affordable option.
- **The unique AutoLens<sup>™</sup>** lens adjustment system dynamically adjusts the lens system to optimize voltage for each element.
- **HF-resistant sample introduction system** allows the analysis of corrosive samples.
- **Dual-stage detector** measures both high and low level analytes simultaneously.
- **Rugged construction** means the system will perform even in the most difficult environments with the dirtiest of samples.

- **Regulatory compliance**

The ELAN 6100 guards against data tampering in conformance with the requirements of regulated industries. The powerful quality control system allows you to set limits, parameters and standards based on U.S. EPA or other quality control guidelines.

- **Ease of use**

Based on the powerful Windows NT<sup>®</sup> operating system, the simple, intuitive software makes ICP-MS accessible to novices and experts alike.

- **Method development made easy**

The PathFinder<sup>™</sup> guide acts as an on-line consultant leading you step-by-step through the method development process.

- **Easy maintenance and low cost of ownership**

System design makes all maintenance easy to perform. Minimal routine maintenance and long-lasting consumables help minimize operating costs.

- **Integrated solutions for every application**

Using a wide selection of options and accessories, PerkinElmer can build a complete, fully integrated system that fits your specific application. The ELAN 6100 is fully compatible with sample introduction accessories such as the FIAS<sup>™</sup>-400MS, HGA<sup>®</sup>-600MS, laser sampling, liquid chromatography, and ultrasonic and micro-flow nebulizers.

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## ICP MASS SPECTROMETRY

### ELAN DRC ICP-MS

For laboratories with demanding applications that extend beyond the capability of conventional ICP-MS, the revolutionary ELAN Dynamic Reaction Cell™ (DRC™) system brings the speed and sensitivity of ICP-MS to new and exciting samples. The ELAN DRC eliminates polyatomic interferences, providing unequaled detection limits for challenging applications.

The unique DRC technology not only reduces the primary interference; it eliminates reaction by-products that create new interferences. The Dynamic Reaction Cell eliminates common polyatomic interferences such as  $\text{ArO}^+$ ,  $\text{ArAr}^+$ ,  $\text{ArCl}^+$ , and many others. This allows sub-ppt levels of elements that cannot be determined easily by conventional ICP-MS, such as Fe, Ca, K, Mg, As, Cr, Se, and V to be determined with ease and without the use of cold plasma conditions.

- **Chemical Resolution** removes interfering polyatomic or isobaric species from the ion beam using controlled ion-molecule chemistry.

- **Dynamic Bandpass Tuning**

The use of a quadrupole inside the reaction cell provides the ability to perform dynamic bandpass tuning, preventing unwanted side reactions from entering the analyzer quadrupole where they can cause additional interferences.

- **ICP-MS Plus...**

The combination of dynamic bandpass tuning and selective reaction chemistry available on the ELAN DRC provides unequaled levels of interference suppression. In addition to the standard features of the ELAN 6100, the ground-breaking interference reduction capabilities of the ELAN DRC provide the most flexible solution for demanding applications, bringing a new dimension to ICP-MS analysis.

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## ICP MASS SPECTROMETRY: LASER ABLATION FOR THE ELAN ICP-MS

**The ELAN 6100 ICP-MS and the ELAN DRC ICP-MS** systems can be directly interfaced with a wide variety of laser ablation systems for performing direct solid sampling. Laser ablation systems using Nd:YAG or excimer lasers provide a powerful, pulsed laser beam which focuses the laser onto the surface of the sample. The resulting vaporized particles are

swept into the ICP Mass Spectrometer with a stream of argon, where they are analyzed in the conventional way. If sample dissolution is a problem, or spatially resolved solid sample analysis is required, then the combination of laser sampling and ICP-MS will ideally suit your requirements.

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## LIQUID CHROMATOGRAPHY / ION CHROMATOGRAPHY COUPLED WITH THE ELAN ICP-MS

**The ELAN ICP-MS systems** can also be coupled with either liquid chromatography (LC) or ion chromatography (IC) systems, providing a complete system for the separation and determination of individual metal species and compounds. The PerkinElmer Series 200

LC pump and autosampler can be completely integrated with the ELAN ICP-MS systems. Combined with Turbochrom™, the industry standard for chromatography software, the ELAN provides a complete solution for your speciation needs.

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## ICP MASS SPECTROMETRY: FLOW INJECTION SYSTEMS (FIAS) FOR THE ELAN ICP-MS

**The PerkinElmer FIAS™-400MS Flow Injection System** enhances the ELAN's sample handling capabilities with numerous features and benefits, including on-line sample preparation, the ability to use microliter sample volumes, increased sample throughput, reduced contamination, and enhanced stability.

Due to the transient nature of the FIAS injection profile, the sample introduction system and the ICP-MS interface are exposed to much lower levels of potentially harsh sample

matrices. This greatly reduces the rate of sample deposition on the interface cones, maximizing stability and reducing the time spent on recalibration and maintenance.

Automated on-line chemistries open up new approaches for difficult analyses. A wide variety of on-line sample preparation techniques are possible, including automated hydride and cold vapor Hg generation, matrix separation, analyte preconcentration and on-line dilution or reagent addition.

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## AUTOSAMPLERS FOR FLAME AND FLOW INJECTION AAS, ICP-OES, AND ICP-MS



The PerkinElmer AS-90plus and AS-93plus series of autosamplers are multipurpose sampling systems for flame and flow injection atomic absorption, ICP-OES and ICP-MS. These autosamplers automate standard and sample introduction for instrument calibration and sample analysis, extending the spectrometer's capabilities to those of a fully automated analytical working station.

The AS-90plus offers fast, accurate sampling with random access for added flexibility. All sampling components are corrosion-resistant for maximum durability and lifetime. Easily interchangeable sample racks accommodate up to 144 samples.

The AS-93plus offers all of the features of the AS-90plus in addition to automatic rinsing with a built-in peristaltic pump. This feature is especially important for ICP applications.

The AS-93plus is compatible with commonly used laboratory sample racks, e.g., Scienceware or Gilson®. Up to 200 samples can be accommodated.

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## FLOW INJECTION SYSTEMS (FIAS)



*FIAS-400 Flow Injection System for Atomic Spectrometry with the optional AS-90 Autosampler.*

The PerkinElmer FIAS™ series of Flow Injection Systems for Atomic Spectrometry (FIAS) provide new levels of automation and sample handling for atomic absorption. Used with flame sampling, the FIAS systems can automatically dilute samples, add reagents or modifiers, remove interfering matrices, or concentrate analyte elements. The FIAS systems also provide a means to automatically analyze microliter sample volumes or sample solutions with exceptionally high amounts of dissolved solids without burner clogging.

FIAS systems can also provide full automation of analyses requiring complex sample preparation, such as cold vapor mercury determinations and hydride generation determinations of As, Se, Te, Bi, Sb, Sn, and other hydride-forming metals.

The entire FIAS series combines simplicity of operation, versatility and exceptional sensitivity with unmatched sample throughput and reduced operating expenses.

For the determination of mercury using cold vapor techniques, FIAS units can use either SnCl<sub>2</sub> or NaBH<sub>4</sub> as the reductant, ensuring compliance with government regulations. FIAS systems also can be equipped with an optional amalgamation attachment which preconcentrates the evolved Hg for significantly lower detection limits.

PerkinElmer FIAS systems are available in a variety of configurations to meet user requirements. All FIAS units are fully compatible with the AS-90 or larger capacity AS-91 flame/FIAS autosampler for fully automated sample handling.

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## FIMS-100 AND FIMS-400 FLOW INJECTION MERCURY SYSTEMS



The FIMS™-100 and FIMS™-400 are compact atomic absorption spectrometers dedicated to the determination of mercury. Based on flow injection (FI) techniques, FIMS is fully automated, fast and cost-effective. The FIMS uses a high-performance single-beam optical system with a low-pressure Hg lamp and solar-blind detector for maximum performance. Automatic baseline offset correction (BOC) immediately before each measurement provides exceptional short- and long-term baseline stability. Full control of the spectrometer, FI components, autosampler and other accessories is via an industry-standard personal computer using PerkinElmer AA WinLab™ software based on the Microsoft® Windows® operating environment.

The instrument's built-in flow injection system allows small sample volumes (10 µL to 1 mL) to be introduced for more rapid analysis times and fewer memory effects than those

resulting from batch or continuous-flow techniques. The injection volume can be varied to compensate for different analytical working ranges. The FIMS-100 has one stepper motor-driven peristaltic pump with a maximum of 8 channels for tubing. The FIMS-400 has two stepper motor-driven peristaltic pumps for greater flexibility when used with the optional accessories.

Detection limits of less than 5 parts-per-trillion can be achieved with the FIMS, and an optional amalgamation accessory can be used to improve detection limits even further.

The FIMS 100/400 can also be used in conjunction with a PerkinElmer AA to expand the capabilities of the system to include all of the features found in PerkinElmer's FIAS™ flow injection systems. These include the determination of the hydride-forming elements via hydride generation and flame-flow injection techniques.

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## MICROWAVE SAMPLE PREPARATION SYSTEM



The Multiwave® Microwave Sample Preparation System is a versatile and powerful microwave sample preparation system that is easy to operate and ideally suited for atomic spectroscopy techniques. It offers:

- **Short analysis time** due to fast and simultaneous decomposition of six to 12 samples and short cool-down time with a built-in high-performance cooling system.
- **Superior decomposition quality** in closed quartz or fluoropolymer (TFM/PFA) vessels for minimum risk of sample contamination.
- **Operating pressures** ranging from 20 bar (300 psi) to 75 bar (1100 psi).
- High digestion temperature up to 300°C.
- Unpulsed microwave power output from 0 – 1000 W.

- **Continuous temperature and pressure control** in each vessel, such as simultaneous pressure control in all vessels with PIC (Pressure Increase Control) software, metal alloy rupture disk, high-strength PEEK protection jackets around the digestion vessels, and a protective shield on the door.
- **Additional accessories** for drying, evaporation, and stirring during the digestion process are available to make the multiwave a versatile sample preparation tool for modern laboratories.

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## CONSUMABLES AND ACCESSORIES CATALOG

PerkinElmer offers a catalog featuring a complete line of accessories and replacement consumable items to complement and enhance the performance of your atomic spectroscopy instrumentation. From autosamplers to Z-fold printer paper, we provide the

tools you need to take full advantage of your PerkinElmer atomic spectroscopy systems. Contact us today for a copy of PerkinElmer's accessories/consumables catalog which is also available online at: [www.orderessentials.com](http://www.orderessentials.com)

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## You can depend on PerkinElmer . . .

as your partner in providing total solutions for your analytical needs. Our comprehensive support system is designed to help your lab operate with greater accuracy, efficiency and productivity.

## Financing Programs

PerkinElmer has a suite of leasing programs to complement the needs of today's companies. In most cases, you can finance 100% of the instrument, software and maintenance—or customize your own lease.

## Unparalleled Customer Support

Most importantly, we've assembled a worldwide support team that's unparalleled in the industry—highly trained, knowledgeable people standing by to make sure you always get the assistance you need, when you need it, whether on-site, on-line, or over the phone.

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For more information, contact your local PerkinElmer representative, or fill out and mail/fax the attached business reply card, visit our website at: [www.perkinelmer.com](http://www.perkinelmer.com), email us at: [info@perkin-elmer.com](mailto:info@perkin-elmer.com), Tel: (+1) 203-762-4000 or 800-762-4000, or Fax (+1) 203-762-4228.



PerkinElmer Instruments  
761 Main Avenue  
Norwalk, CT 06859-0010 USA  
Phone: (800) 762-4000 or  
(+1) 203-762-4000  
Fax: (+1) 203-762-4228  
[www.perkinelmer.com](http://www.perkinelmer.com)



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