by Richard Green

Lead Exposure Lab Blood Tests Look to Atomic Absorption Spectroscopy for Economies

State regulations and looming budget cuts force laboratories to look for ways to reduce costs and improve efficiencies. Here's one solution.

Many children with moderate long-term exposure to lead show reduced short term memory, delayed reaction time, reduced ability to concentrate, and diminished scores on IQ tests. Although no comprehensive data are currently available, a 2003 survey by the Illinois Department of Public Health estimated that one out of every 15 children under the age of seven have unacceptable levels of lead in their blood.

Decades of use of lead in paint, gasoline, plumbing systems, and a myriad of other products has left these high blood lead levels as their poisonous legacy.

By law, all children entering any school in Illinois must be tested for lead poisoning. Left unchecked, lead poisoning will stunt a child's development and cause behavior problems.

Paint produced prior to 1978 is the leading source of lead contamination. Not only do high levels of lead contribute to learning disabilities in children, but exposure to these levels also has been linked to high blood pressure in adults.

A Search for the Most Effective Method

The question posited is: ***What is the most effective and economical means for the detection of lead in the blood stream?***

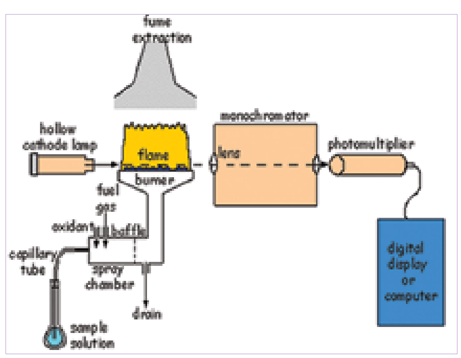
Atomic absorption spectroscopy (AA or AAS) offers the technology that many laboratories use to process the high volume of blood samples received every year. As indicated in Figure 1, atomic absorption simply converts complex samples into an elemental form for identification and for determining concentration.

The following details offer an insight into the basic AA blood analysis procedure that identifies metals through the interaction of light and matter. Additionally, this article evaluates the gas control equipment required to maximize safety and productivity, and includes the specialty gas parameters and considerations that enhance its understanding.

Atomic-absorption (AA) spectroscopy uses the absorption of light to measure the concentration of gas-phase atoms. Analyte atoms or ions must be vaporized in a flame or graphite furnace. The atoms absorb ultraviolet or visible light and make transitions to higher electronic energy levels. The analyte concentration is determined from the amount of

Fig. 1 Schematic diagram of atomic absorption spectrometer

Atomic absorption spectrophotometry (AAS) is an analytical technique used to measure a wide range of elements in materials. Although it is a destructive technique, the sample size needed is very small (typically about 10 milligrams) and its removal causes little damage. The sample solution is accurately weighed and sprayed into the flame of the instrument and atomized (see schematic diagram). Light of a suitable wavelength for a particular element is shone through the flame, and some of this light is absorbed by the atoms of the sample. The amount of light absorbed is proportional to the concentration of the element in the solution, and hence in the original object. Measurements are made separately for each element of interest in turn to achieve a complete analysis of an object, and thus the technique is relatively slow to use. However, it is very sensitive and it can measure trace elements down to the parts per million level, as well as being able to measure elements present in minor and major amounts.



absorption, with concentration usually determined from a working curve after the instrument is calibrated.

The Evaluation Process

In the first stage, multiple blood samples are loaded into an AAS auto-injection carousel; each sample is drawn or aspirated into the nebulizer chamber and mixed with air/acetylene or nitrous-oxide/acetylene. During this stage, the mixture is reduced in the ignited air/fuel flame to its elemental form. Light is then generated from a cathode lamp at a wavelength readily absorbed by the element analyzed and is illuminated through the flame.

When it is in an excited state, lead absorbs light with a specific wavelength of 283.3 nanometers. The resultant light is passed through a monochromator to remove other wavelengths that have been generated by the flame. (*A monochromator is an optical device that transmits a mechanically selectable narrow band of wavelengths of light or other radiation chosen from a wider range of wavelengths available at the input.*) Only the narrow spectral photon line of interest is radiated onto the detector. A signal processor then converts the radiation into an electrical current proportional to the amount of lead in the sample. An inverse relationship yields less spectral intensity on the detector (i.e., greater absorption) when higher concentrations of the subject element are present in the sample.

Atomization and excitation occur in the inert argon atmosphere. The sample is then flushed out of the vaporization chamber by the argon carrier gas.

Where a graphite furnace is used, its chamber must be cleaned at 2,800C to prepare for the next sample. Otherwise, a de-ionized water or a diluted acid solution is aspirated between samples. The process takes an elapsed time of three minutes per sample, or three hours per carousel.

Economies Pushed by Regulations

Increasingly stringent state regulations and looming budget reductions, are forcing laboratories to find ways to reduce costs and improving efficiencies. Through prudent application, both gains and enhanced laboratory safety can be achieved at the same time.

Fig 2. Differential pressure gas switchover manifold.

One of the first steps that can be taken to reduce costs in the laboratory is to set up a central gas supply system and relocate the cylinders in the laboratory. A differential pressure gas switch-over manifold (Figure 2) plays a key role in such a system. With this setup, monthly cylinder rental is reduced since multiple instruments can be supplied with only two acetylene cylinders.

Also, operator safety is enhanced when cylinders are relocated to a separate, dedicated location, away from ignition sources. Relocation is vital because small system leaks allow acetylene to displace atmosphere below the human breathing zone, permitting where an undetected ignitable mixture to build up.

Secondly, the cost of argon (the carrier gas) can be reduced by switching to the supply to liquid cylinders. By volume, approximately 15 high-pressure cylinders can be replaced with one 200L liquid cylinder.

NOTE: The advantages of reduced handling and lower unit costs can be nullified if liquid cylinder vent and residual return losses are not minimized. Pressure differential switch-over technology does not adequately address liquid cylinder pressure building and economizer dynamics to reduce these losses.

Figure 3. Acetylene pressure differential gas switchover system.

New developments in switch-over manifold technology (Figure 3) have enhanced safety and reduced costs even further. These new manifolds utilize intelligent software to analyze the output of pressure transducers in a cylinder bank and make it possible to prioritize them in a logical manner to reduce vent and residual losses. Gas waste is eliminated without sacrificing the quality of argon to the instruments. This gas switchover technology translates into savings of several hundred dollars per year with when requirements for argon are reduced to one liquid cylinder per week.

Figure 4. Point of use panel that regulates process gas pressure and flow.

An ancillary benefit to a laboratory is the increased productivity gained by eliminating the downtime experienced when empty cylinders are switched out.

Also, laboratory space gained when cylinders are moved out can be optimized since additional equipment and personnel can be added.

Gas setup and monitoring is achieved by piping the output of the remote gas switchover to a point-of-use panel or wall mounted regulator and flowmeter (Figure 4.) Local alarms and notification systems enable the laboratory technicians to focus on the blood analysis process without the distraction associated with tracking the contents of each cylinder.

This win-win solution demonstrates that laboratory safety and productivity can both be achieved.

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