

Spectrochem Instruments Pvt. Ltd.



Hydride Generator User Manual

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Continuous Hydride Generator

Atomic absorption spectrochemical analysis of As, Sb, Bi, Sn and Pb have good detection limits in the range 1-5 ppm per ml of solutions aspirated in to the flame. However, the signal due to As at 197.3 nm is absorbed by flame and transparent flames are recommended viz., air-hydrogen no better detection limit than 1 ppm.

These hydride forming elements can react readily with Sodium Borohydride resulting in the formation of the respective elemental hydride. The technique in fact works as a concentration method since only hydride gas is allowed to escape in to open ended quartz sample tube that is mounted on the air acetylene burner of the equipment and heated by the flame. The-hydride thus generated is decomposed at the flame temperature and creates the required ground atoms that absorb the incoming radiation of the elemental hollow cathode lamp. By this method the detection that can be achieved are better than the normal flame technique.

In the 80's most of the instrument manufacturers sold Hydride Generators having pellet dispenser for Borohydride, with a mechanical stirrer, a gas purge unit. A few ml of the sample is injected into a reaction chamber, a pellet of Borohydride is added and the resultant elemental hydride gas is flushed into the cell using a low volume flow of nitrogen gas. The basic disadvantage of such system is the transient nature of the signal, since the hydride is not generated continuously. Also the release of hydride is slow and the peak height is not a correct measure and signal is spread broadly.

With the advent of flow injection analysis equipment, metal hydride can be generated continuously and fed into the flame cell unit. With this new development the signal giving species is available continuously and the instrument produces a stable signal output. Thus all the disadvantages of the old method have been rectified and better detection limits in nano-gram range are obtainable.

Applications:

Water & effluents

As usual in atomic absorption the analysis of water and effluents is a straight forward application because the sample is in the liquid form. Standard addition method is to be employed invariably since no standards are available. The purity of **the** Borohydride and the acids employed and also the quality of water employed have direct bearing on the analysis. Many authors reported use of special grades of chemicals such as Suprapure of E.Merck and water of MilliQ reagent grade having resistance of 18 M.ohms (typical total impurities less than 1 ppm).

Typical values for portable water , As 0.0005, Bi 0.00004, Ge 1.0, Pb 0.08, Sb .0006, Se 0.0002, Sn

0.0004, Te 0.002 micro grams

Metallurgical

Probably the most severe interferences encountered for any application in hydride generation occur in metallurgical samples. For example the interference of copper on the absorption of selenium is very severe, almost completely suppressing the selenium absorption signal unless the copper is first separated. The determination of As, Bi, Se, Sn, and Te in copper and its alloys can be achieved after co-precipitation of these elements with Lanthanum hydroxide. Similarly interference caused by nickel in high temperature alloys while determination Bi and As can be removed by addition of EDTA, Analysis of these elements in steels encounter interferences due to constituent elements. By employing standard addition method, precise and accurate analysis of these elements can be achieved. In most metallurgical samples some sort of pre-treatment is required to achieve precise analysis. The chemistry and the chemical manipulations that are normally performed on metallurgical samples need good knowledge of analytical chemistry. The analysis of these hydride forming elements in diverse metallurgical samples have been reported in literature. A good survey is a must for development of methods.

Foods : The hydride generation technique has found wide application in the determination of toxic metals in foods and drinks. The analysis of wine, sherry and beer samples present no serious analytical problem. However acidification and degassing of the sample must be carried out before the analysis.

Water soluble foods like sugar, coffee and organic coloring agents can be analyzed directly once a suitable solution is made. For other food samples a digestion process is necessary before reduction to the hydride and the most of the published work deals with these methods. Typically 2 - 5 grams of the food sample is digested in a conical flask with 5 ml of conc. Sulphuric acid 50% m/v hydrogen peroxide until a clear sample solution is obtained. Also sulphuric and perchloric acid mixtures are also employed. One has to take good care while using perchloric acid due its hazardous oxidative power on organic substance. Yet another proven method is the digestion of the sample in a Kjeldahl flask with a 4:1:1 mixture of conc. Nitric, sulphuric and perchloric acids. Recent addition of microwave digestion equipment and the related accessories also improve the sample preparation methods.

Clinical : The toxicity of the some of the hydride forming elements such as As, Sb, Pb and to some extent Bi of human metabolism is well documented. Analysis of these hydride forming elements cannot be done directly on the samples and need careful and elaborate digestion procedures. Recent addition of microwave digesters has simplified many digestion procedures. Once a clear solution is obtained standard addition method can be employed for obtaining precise and accurate analysis in the absence of certified standards.

Agricultural : Arsenic occurs in minerals at various levels and the use of arsenic compounds in the pesticide formulations, its dispersal in the environment requires monitoring in soils and plants. Most of the published data deal with only As and Se, the same methods can be employed for other hydride forming elements when analysis is required. Normally mixed acids such as nitric, sulphuric and perchloric or peroxide fusions are recommended for sample treatment. Dry as well as wet ashing and also microwave digestion are also successfully employed by various authors. A few SRMs are available from NIST USA for such analysis.

Geological: Rocks and minerals are very complex samples chemically and the sample preparation techniques are involved and cumbersome. Also enough care and skill in handling on the part of chemist is a must. When employed properly the method offers good accuracy and precision. Well characterized SRMs are to be employed (US GS rock stds and NIST mineral stds) Many laboratories in other countries are using flux digesters and microwave digesters and also ROBOTIC equipment for analyzing large numbers of geological samples.

Operating Instructions

THE NEW VAPOUR GENERATOR ACCESSORY(HYDRIDE GENERATOR) consists of two cassette type peristaltic pumps that ensures uniform and independent reagent control. The cassettes have a pressure applicator ratchet The top pump is meant for reagents and the lower pump ensures the sample addition to the system

In effect this system is akin to a low pressure liquid chromatograph. The above described pumps, pump the reagents and the sample to a meter long Teflon column, wherein the reaction occurs. The sample coming from the lower pump is first mixed with acid coming from the first cassette of the top pump and as the liquids pass and then addition of the boro-hydride solution stabilized with hydroxide solution is affected.

As a consequence of the reaction the nascent hydrogen generated will react with the hydride forming element (say As etc) to form AsH₃



As the liquids and the gases proceed in the column, the residence time provided will ensure complete reaction. At the end of the column a gas liquid separator in the form of a H-bridge will ensure the draining of the liquids. The hydride gas thus generated is flushed to the flame/ flame less cell mounted on

the burner compartment of the AAS in the light path.

A) FLAME CELL MADE OF QUARTZ CAN WITHSTAND FLAME TEMPERATURE IN CASE OF ANALYSES OF ALL HYDRIDE FORMING ELEMENTS EXCEPT MERCURY ONLY THIS CELL IS TO BE USED.

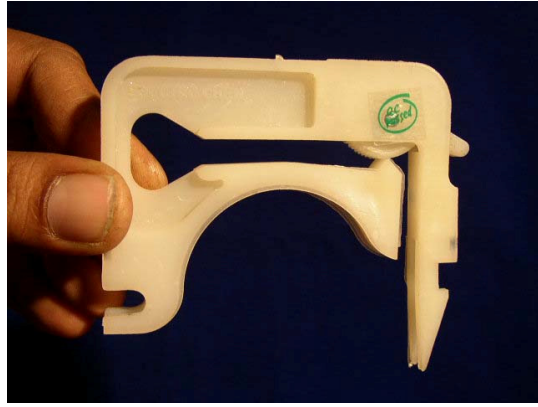
Note: Position the flame cell on the burner and optimize cathode lamp intensity to have maximum output. This step will ensure the the cell is not blocking the optical path. This operation is to be performed carefully each time the burner position is altered, height or lateral or rotation. Some times all the three operations may need to ensure full optical through put.

B) Mercury cell. The cell is unique having UV transparent removable windows, unlike other makes. One can clean the system by removing the window holders and placing the glass cell in 2% nitric acid. Since the cell is used only for HG COLD VAPOUR it is fabricated out of BOROSILICATE GLASS.

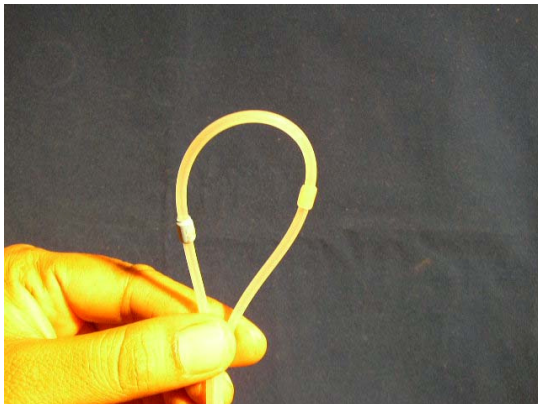
Caution: never ignite flame with this cell on the burner mount, since you will damage the system permanently.

C) Yet another advantage of this unique system is that you can switch off any of the pumps. This will facilitate saving of the highly expensive reagent by switching of the pump one while blank setting and while changing standards and the samples (where the reagent are simply being wasted in operation)

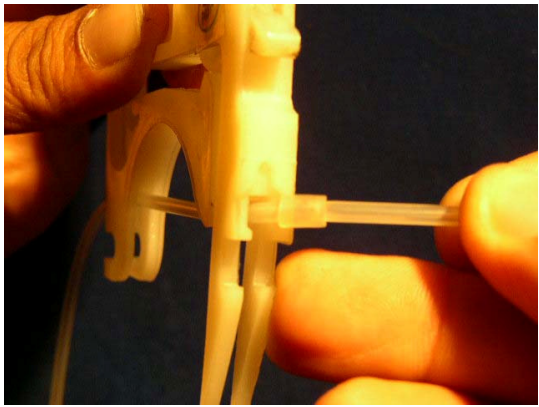
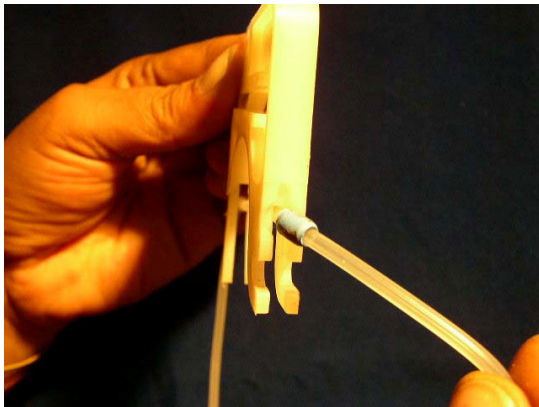
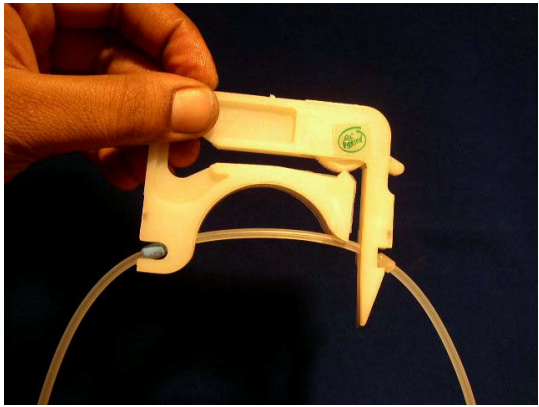
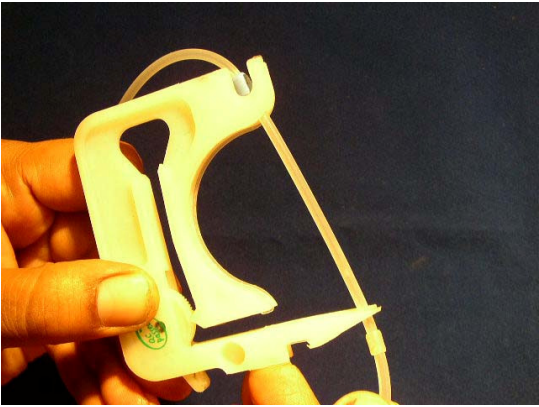
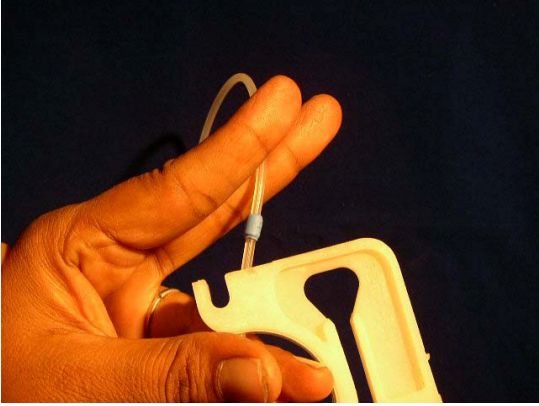
D) Loading the cassette with the tubes and the positioning of the cassette on the pump rollers is shown in the illustration. Move the ratchet by one step each time to ensure proper priming. Excessive pressure will permanently damage the tubing needing replacement.



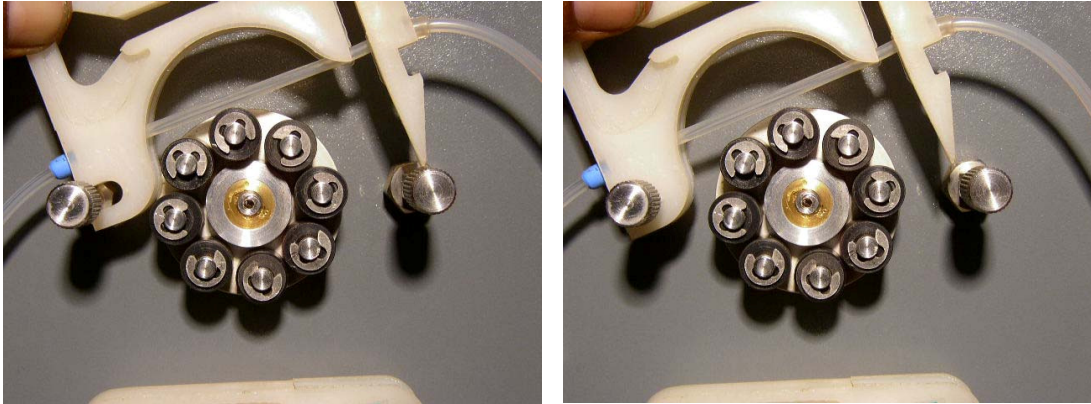
The roller cage with the cassette mounting studs and the cassette (front face) is illustrated above.



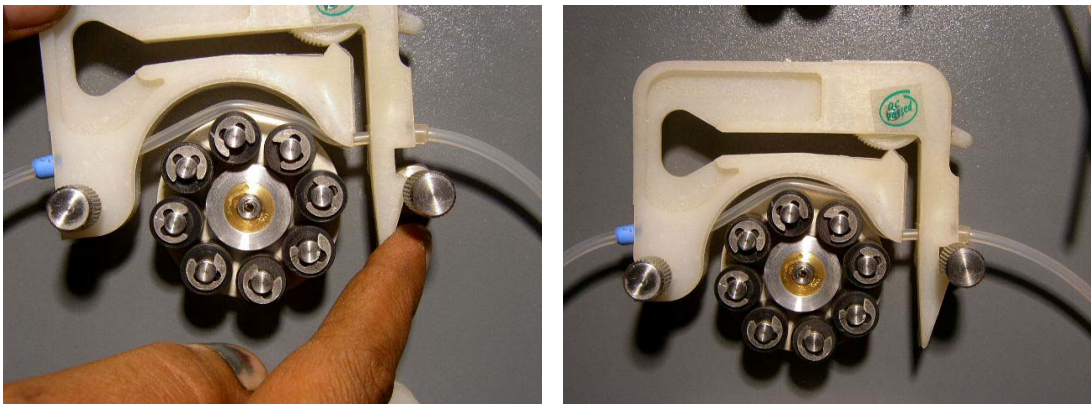
The picture above illustrates the silicon pump tubing. The pump tubing has two stops. These stops get engaged in the cassette and prevent the tube from being dragged during the pumping. The first stop is colored, in this case blue; this stop is the fixed stop. This cannot be moved and is always mounted to the left as you look into the front face of the cassette. Also the motor direction dictates the side the fixed stop is mounted. In this pumping system the motor direction is fixed (Clock wise) and cannot be changed. The other stop is in the same color of the tubing (transparent) and is movable. This option is provided to adjust the tension between the fixed & movable end of the tubing.



The next step is to load the cassette on to the pump head. The procedure is illustrated below.



Engage the hook end of the cassette on to the left side stud (round one). Next move in the pointed side of the cassette until it is within the second square stud. Push the cassette down until it latches into the square notch on the pointed side of the cassette.



Once the cassette is loaded, the pressure applicator ratchet need to be adjusted until the pump begins to pump the liquid. Moving the ratchet as illustrated in the picture to the left may do this.



Caution: Never- set the thumb wheel switch to zero and. try to rotate the cage assembly of the respective pump unit. This could lead to permanent damage to the stepper motor.

Pumps: Installation of pump tubing:

Always install low flow tubing 0.75 mm bore on Pump-1 and high flow 1.0 mm bore on Pump-2. Mount the fixed end (Color coded end) on the left hand side.

Pump 1: On pump I two channels are required to give equal pumping rates of acid and Borohydride. Run a low flow tube in one cassette where the pressure applicator is in the lowest position. Load the cassette on to the roller cage, ensure that the pressure applicator is at the lowest position. Similarly place the second cassette also. Run the pump and adjust the ratchet of each cassette to initiate liquid flow. Once the flow is established, advance the ratchet by one step extra to ensure proper pressure.

Pump 2: The pump 2 supplies the sample solution to the reaction column via mixing manifold. Install the tubing exactly like in case of pump 1 and ensure the pressure is even to ensure pumping.

Flow calibration: The next logical step is to calibrate the pumps to deliver the desired flow of the liquids. Extensive experimentation was conducted to determine the required settings on the thumb wheels (i.e rpm control set) for the right flow. This data is appended on a separate sheet at the end of this manual. A flow rate of 2 ml on pump 1 is obtainable for a thumb wheel setting of 5 (50RPM). However due to inconsistencies in the tube inner diameters sometimes one may have to set to either 4 or 6 as the case may be. On the other pump .for a flow rate 5-6 ml a setting of 8 on TWS is ideal. Here again for the same reason mentioned above you may have to choose an alternate setting.

Note: A very important consideration is the pressure applicator setting. The ratchet applies the required pinching pressure on the tubing by the rollers to initiate the liquid flow as well as maintain a constant flow. A proper setting is to select the position such that the pump gets primed automatically. Excessive pressure shortens the tube life unduly. Allow sufficient time after every adjustment of the pressure ratchet for auto priming to occur. The pressure ratchet can be advanced by a step each time. If the pressure is insufficient no pumping action is observed. In case of pump 1 where two tubes have to pump the same flow rate a little more caution is to be exercised (if the flow rates match within 0.2 ml the settings can be considered OK).

Connections: Connect one of the tubes color coded side to Borohydride and the other tube similarly to acid. The other ends of these tubes have to be connected to the mixing manifold. These connections are always on the top side of the manifold. The front facing connection is meant for the sample only. In case this

sequence is not followed the results are unpredictable.

Gas Connections: Connect the 6.35 mm poly flow tubing to the bulk head connector provided on the back panel of the equipment marked GAS IN. Switch on the toggle switch by lifting upright to on position and set the needle valve of the flow meter to the desired reading of 0.2 to 0.4 liters per minute. The gas circuit is designed to operate on a moderate pressure of 5-10 psig from a controlled flow of gas via a two stage regulator.

Drain: The gas-liquid separator unit has a soft Silicone tube connected to the drain outlet. Guide the tube underneath the unit and allow the tube to drop straight to the floor from the table top. The end of the tube can be placed in a 2.5 liter bottle to collect the waste liquids. If the tube is twisted, etc drain fouling may result.

Hydride Connection: A Teflon FEP, tube is provided at the rear of the instrument. A Silicone tube is provided to connect the unit to quartz cell.

Maintenance: Each time after use of the equipment disconnect the acid and Borohydride bottle connections and along with the sample tube of the other pump place in a beaker of distilled water. Pump water for at least five minutes to ensure clean up of the flow through system. This operation will ensure that the system is 'ready for operation next time.

The peristaltic pump tubing are expected to last minimum of 100 hours at normal operating conditions. In case one tube of pump 1 is punctured, better replace both the tubes so that the same flow rates are obtained. The used tube can be saved and reused along with another used tube.

Periodic Maintenance:

- Check the pump tubing's by pumping distilled water every week.
- Check the drain for proper functioning. *A good drain function is indicated by a series of air and liquid bubbles' leaving the unit.*
- Inspect the inlet tubes of the mixing manifold for nicks. In case any are found replace them. The same is the case with the take up tubes of Borohydride, acid and sample.
- Spray a squirt of ZORICK lubricant on the rollers every ten days.

Basic Tips & Trouble shooting: It is recommended that the concentration of Borohydride is always in excess by 0.25% in the resultant solution for obtaining consistent absorbance readings. It is advised to use de-ionized and distilled water in the entire chemical manipulations. The reagents must be of superior grade than the normal analytical grade. The gas flow rate also affects the absorbance and the best results can be obtained in the range of 0.2-0.3 liters per minute.

Trouble shooting:

- If the instrument does not come on i.e. the switch indicator light on the rear panel does not glow, first check whether the unit is plugged into the mains. Next check to see if the power cord on the back panel is correctly plugged in.
- Switch indicator lamp glows but the motors do not rotate. Check whether the fuse on the rear panel is OK, If the problem persists then call the service since there are no user serviceable parts inside the unit.
- If it is observed that only one channel of the pump I is active, check if the pressure applicator and arm are aligned properly. This problem can be corrected by setting the pressure applicator to the correct position as per the instructions above.
- If only pump 1 or pump 2 is active i.e. pumping the liquids shut down the active pump by setting the TWS of that unit temporarily on “0” and adjust the ratchet of the second until flow is observed in the second pump. This way any air lock is eliminated.

Analytical Methods

Factors affecting the formation of Hydrides.

Acid Concentration: The concentration of acid will affect the efficiency of hydride formation in the hydride/vapor generation accessory. You must ensure that the acid concentration of blank, standards and sample solutions are the same.

The figure (I) shows the effect of acid concentration on the absorbance of various hydride forming elements. For the multi element analysis, a compromise acid concentration will be required, NOTE; The use of oxidizing acids (e.g. sulphuric and perchloric) should be avoided.

Oxidation state: The hydride forming elements may exist in more than one oxidation state in sample or standards. This can have dramatic effects on the measured signal.

For example for Te and Se a 10 X or more increase in the signal intensity is observed if the lower oxidation state is prepared.

Solutions containing sulphuric and perchloric acids may give little or no signal for any hydride forming elements. The use of sulphuric and perchloric acids is to be avoided as these are very strong oxidizing agents. In general.. 1000 ppm standards exist in the higher order oxidation state. For this reason, sample and standard and blank solution MUST be prepared by a similar method to obtain the lower oxidation state. Mild reduction with HCL simmered on a hot plate can be effective in this respect.

Interferences: The measurement of some elements by VGA can be affected by the presence of other elements or molecules in the sample matrix. These reduce the amount of element detected by the spectrometer by adversely affecting the amount of hydride formed.

A list of observed interferences is given "herewith.

Contamination: When first establishing your analytical method you must always check for contamination before carrying out your program. Note particularly the traces of potassium iodide will interfere severely with the determination of Bi, Hg, Se and Te. You must always ensure that the VGA system is completely free from residual KI before attempting to determine these elements.

The most practical way of minimizing contamination problem is to provide a separate module (including the reagent containers and pump tubes for these elements).

Another form of contamination can occur when changing from a high level standard to a low level standard. You must make sure that all tubing in the module are thoroughly rinsed.

Memory Effects: Because the VGA uses a chemical reaction to produce the elemental hydrides, some memory effects can be encountered in the reaction products when changing between low and high level standards. Always allow several minutes when moving from a high to a low level standard. You should also ensure that the standards are prepared at the same concentration as the samples. Certain type plastics can cause memory effects for mercury. Keep mercury high standards as low as practicable.

Background Absorption (AA only)

IN GENERAL, BACKGROUND CORRECTION IS NOT NECESSARY FOR A VAPOR GENERATION WORK, Occasional exceptions may be encountered. For example, when determining low level As in the presence of another hydride forming element.

You should establish whether background absorption is occurring before carrying out your analytical program. This can be done by analyzing a sample with a background correction on and then repeating the analysis when it is off. (Make sure that you do an instrument zero before each measurement).

If a significant difference is found between the two measurements, then only perform analysis with background correction on. If there is no difference, then level background correction off.

Laboratory Procedures: General; The vapor generation technique demands a particularly high standard of care in the entire activities which affect the accuracy and precision of the analytical results. Scrupulous cleanliness is essential in all laboratory procedures; standards and samples must be meticulously prepared, and carefully handled. Strict precautions must be taken to avoid contamination of apparatus and even though laboratory wear is stored under ideal conditions, it should be thoroughly re-washed before use.

Strict care should also be taken to avoid contamination of all reagents and distilled water, ideally, reagents should be entirely free from the element of interest, but this is obviously impossible for all analyte elements in all reagents, Consequently, you must always establish the level of analytical signal attributable to analyte in the reagents. It is of course standard practice to check the analytical signal from the blank solution before calibrating the instrument and carrying out the analytical program. With the VGA, however, this procedure must be extended to include the acid and sodium Borohydride solutions pumped through the system.

Standards: PREPARE YOUR CALIBRATION STANDARDS FROM 1000 ppm stock solutions, fresh every occasion and ensure the required addition of acid and use only double distilled water.

For some samples it will be necessary to compare calibration slopes using the normal calibration, method with those obtained using the standard addition method. If the slope is not the same, you should use the standard addition technique for the analysis.

Reductant - Sodium Borohydride: The recommended sodium Borohydride concentration is 0.5% w/v. However better results will be obtained for difficult samples containing high concentrations of metals if the sodium Borohydride CONCENTRATION IS REDUCED TO 0.3% W/V.

Note: Stannous chloride reductant is recommended for mercury determinations. Always stabilize the solution by first adding sodium hydroxide.(NaOH - 0.5 % w/v). Since sodium Borohydride will decompose significantly in one or more days, you should not prepare more than 500 ml at time. At a flow rate of 1 ml/min. this should be enough for continuous operation over a typical working day. Stability may be improved by passing the solution through a 5 micron filter. You can also extend the working life of the

solution by storing at 5 degrees Celsius (solution will be stable for one week). Always allow the solution to attain the ambient temperature before use.

Pump tubing: The pump tubing should be checked regularly by checking the flow rate.

Note: When concentrated acid is first pumped through the tube, the inside of the tube may change, this however will not impair the tube life or efficiency.

Samples, reagents and standards should all be at room temperature prior to analysis. Pumping rates will vary with solution temperature, and very hot solutions will reduce the life of tubing.

Sources (Lamps for A A only): Good and stable hollow cathode lamps or boosted discharge lamps can be use for VGA work.

Basic Methods: The hydride forming elements may exist in more than one oxidation state in samples and standards. The following analytical methods for sample and standards have been developed to ensure that the' analyte will be present in both the sample and standard in same oxidation state.

Antimony: Prepare samples in at least 1 M hydrochloric acid and ensure that any analyte present as Sb(V) is reduced to Sb(III) by the action of potassium iodide at a concentration of 1% w/v. Reduction is spontaneous and heating should not be required.

Reductant Container	Sodium Borohydride	0.6%
	Sodium hydroxide	0.5%
Acid Container	5 - 10 Molar HO	

Arsenic: NOTE ADDITIONAL NOTES IN THE END

As in the sample must be in the inorganic form, otherwise digestion will be necessary. If digestion is necessary, use acid digestion, ensure no residual oxidizing acid is present, or ashing with an appropriate ashing aid. Simple dry ashing is not recommended.

Prepare samples in at least 1 M HCL.

Ensure that all analyte is present as As (III) by the action of KI at a conc. of 1% w/v.

Reduction will take about 50 minutes at room temperature. The reduction, can also be carried, out at 70 degrees in four minutes, however you must cool the samples and standards to room temperature prior to analysis. If the reduction step is omitted and the analyte is retained at As(V), the analytical sensitivity is about 20-30% of the obtained for As (III).

Reductant Container	Sodium Borohydride	0.6%
	Sodium hydroxide	0.5%
Acid Container	5 - 10 Molar HCL	

Bismuth: THE PRESENCE OF POTASSIUM IODIDE WILL SEVERELY SUPPRESS THE ANALYTICAL RESPONSE. Always ensure the VGA system is completely free of KI by pumping 0.5% w/v sodium hydroxide solution for at least one hour, followed by distilled water for 10 minutes and by 1 M HCl for 30 minutes followed by 10 minutes distilled water.

Note: In case of heavy work load for As, Sb, Se analysis by VGA and also moderate load for the determination of other hydride forming elements it is advisable to have systems designated for each use.

Prepare the samples in 1 M HCl

Reductant Container	Sodium Borohydride	0.6%
	Sodium hydroxide	0.5%
Acid Container	5-10 Molar HCl (higher acid will depress The analyte signal)	

Tellurium: the presence of KI will suppress the analyte signal heavily. A wash sequence is recommended. Te(VI) is also not quantitatively recovered by the hydride generation and hence the reduction to Te(IV) by the action of hot 70-90 degrees 6-7 Hcl for at least 10-15 minutes is recommended. Cool the solution before the analysis.

Reductant Container	Sodium Borohydride	0.6%
	Sodium hydroxide	0.5%

Acid Container	5-10 Molar HCl (higher acid conc will reduce the analyte signal.
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Tin: The best results for Tin will be obtained from solutions having prepared in 1% tartaric acid. Also it was reported that addition of L-cysteine generally improves the determination of tin by hydride technique. The L-cysteine reduces metal interferences and improves precision and accuracy. This has also improves the linearity of the calibration curves. The amount of acid pumped is also important and acid higher than 0.5 M severely depresses the signal. It is essential to determine tin at the 286.3 nm wavelength and 0.2 nm slits. The 235.5 nm line and 224.6 nm line shows poor response and lower dynamic range.

Reductant Container	Sodium Borohydride	0.6%
	Sodium hydroxide	0.5%

Acid Container	5-10 Molar HCl
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Sample	Double distilled water
	1% Nitric Acid
	1 % I-Cysteine

Additional Notes

- If As and Se are both to be determined from the same sample, determine Se first and avoid KI in sample and standards. Then As can be determined after the KI. reduction step and any other appropriate treatment such as addition of urea to remove excess nitric acid.
- For the determination of As and Se many practical samples containing high concentration of metals such as copper, iron, nickel fewer interferences are observed while using 0.3% sodium Borohydride. Use of lower Borohydride concentration will give less signal intensities.
- Transitional elemental interferences can be minimized while determining As and Se by preparing the samples in 6-7 M HCl, with lower acid the interferences are more pronounced.
- Co-precipitation methods using Lanthanum as carrier having been found useful.

INTERFERENCES

The measurement of some elements by VGA can be affected by the presence of other elements or molecules in the sample matrix. These reduce the amount of element detected by the spectrometer by adversely affecting the amount of hydride formed. A list observed interferences is given in the table below.

Analyte	50%	10-50%	10%
As	Au, Ge, Ni, Pt, Pd, Rh, Ru	Ag, Bi, Co, Cu, Sb, Se, Sn, Te	Al, B, Be, Ca, Cd, Cr, Cs, Fe, Ga, Hf, Hg, In, Ir, K, La, Li, Mg, Mn, Mo, Na, Pb, Re, Si, Sr, Ti, Ti, V, W, Y, Zr, Zn, Rb.
Bi	Ag, Au, Co, Cu, Ni, Pd, Pt, Rh, Ru, Se, Te.	As, Cd, Cr Fe, Ir, Mo, Sb, Sn	Al, B, Be, Ca, Cs Ga, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Pb, Rb, Re, Si, Sr, Ti, Tl, V, W, Y, Zn, Zr.
Ge	As, Au, Cd, Co Ni, Pd, Pt, Rh, Ru, Sn, Sb, Se	Bi, Cu, Ir, Te	Al, Ag, B, Ba, Be Ca, Cr, Cs, Ga, Hf, Hg, In, K, La Li, Mg, Mn, Mo, Na, Pb, Rb, Si, Sr, Ti, Tl, V, W, Y, Zn, Zr
Sb	Au, Co, Ge, Ni Pt, Pd, Rh, Ru.	Ag, As, Cr, Cu, Re, Se, Sn.	Al, B, Ba, Bi, Ca, Cd Cs, Fe, Be, Ga, Hf, Hg, In, Ir, K, La, Li, Mh, Mn, Mo, Na, Pb Rb, Si, Sr, Ti, Tl, V, W, Y, Zn, Zr.
Se	Ag, Cu, Ni, Pd, Cu, Fe, Ge, In, Ni, Pb, Pd, Pt, Re, Rh, Ru, Se Sn.	Au, As, Cd, Co, Si, W.	Al, B, Bi, Ba, Ca, Cr, Cs, Ga, Hf, Hg K, La, Li, Mg, Mn, Na, Rb, Sr, Ti, V, Y, Zn, Zr.
Te	Ag, Au, Cd, Co Cu, Fe, Ge, In, Ni, Pb, Pd, Pt, Re, Rh, Ru, Se Sn,	As, Bi, Ir, Mo, Sb, Si, W.	Al, B, Ba, Be, Ca, Cr, Cs, Ga, Hf, Hg K, La, Li, Mg, Mn, Na, Rb, Sr, Ti, V, . Y, Zn, Zr.

% LOSS OF ANALYTE SIGNAL DUE TO ELEMENT INTERFERENCES.