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Albuquerque Bernalillo County

Water Utility Department

WATER RECLAMATION DIVISION
4201 2ND STREET SW, ALBUQUERQUE, NEW MEXICO 87105

WATER QUALITY LABORATORY
STANDARD OPERATING PROCEDURE APPROVAL FORM

WQL SOP **505 ICP-OES**

CURRENT REVISION # **03** DATE **August 14, 2006**

ORIGINAL ISSUE DATE **July 1997**

MODIFICATIONS AND REASONS FOR REVISION

❖ 2006 A2LA Audit Requirements
❖ Deficiency 16; SOP revised to reflect current maintenance practices.

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PUBLIC WORKS DEPARTMENT
WASTEWATER UTILITY DIVISION
ENVIRONMENTAL SERVICES SECTION
TECHNICAL PROGRAMS UNIT

WATER QUALITY LABORATORY

STANDARD OPERATING PROCEDURE APPROVAL FORM

WQLSOP

SP/OPTIMA 3000

PERKIN-ELMER OPTIMA 3000 DV ICP EMISSION SPECTROMETER

CURRENT REVISION # **01** DATE **07/07/97**

MODIFICATIONS AND REASONS

**Replacement of Plasma II Emission Spectometer
**Detailed Instrument Operation and Corrective Actions
**Detailed QA/QC Requirements
**Incorporated 3 point Calibration
**Detailed Safety and Analyst Training
**Detailed Maintenance and Troubleshooting

LABORATORY QUALITY MANAGER _____ DATE 5-13-98

CHEMICAL HYGIENE OFFICER _____ DATE 5/13/98

LABORATORY MANAGER _____ DATE 5-13-98

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WATER QUALITY LABORATORY

STANDARD OPERATING PROCEDURES

PERKIN-ELMER OPTIMA 3000

SPECTROMETER

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1.0 SCOPE AND APPLICATION

1.1 This procedure is applicable to the determination of aluminum, boron, barium, beryllium, calcium, cobalt, copper, iron, lead, nickel, magnesium, manganese, molybdenum, potassium, silver, silicon as SiO2, sodium, strontium, vanadium, zinc.

1.2 Inductively coupled plasma-atomic emission spectrometry is used to determine metals and some nonmetals in solution. These procedures are applicable to a large number of metals in drinking waters, industrial waste, treatment process control, urban storm water runoff, and environmental health monitoring samples.

1.3 Metals analytical technique and method detection limits of this procedure are shown in Attachment 1.1.

1.4 For reference where this method is approved for use in compliance monitoring programs [e.g., Clean Water Act (NPDES) or Safe Drinking Water Act (SDWA)] consult both the appropriate sections of the Code of Federal Regulation (40 CFR Part 136 Table 1B for NPDES, and Part 141 & 141.23 for drinking water), and the latest Federal Register announcements.

1.5 All ICP analyses will be conducted according to Method 3120B 18th Edition of Standard Methods.

1.6 Reference EPA Method 200.7 Metals Direct Inductively Coupled Plasma Emissions.

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2.0 SUMMARY OF PRINCIPLES AND PROCEDURES

2.1 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 to 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 most critical components of atomic emission instruments is the atomization source, because it must provide sufficient energy to excite the atoms as well as to atomize them. See Figure 2.1

2.2 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. 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. Radio frequency (RF) power is applied through the coil, and on 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 (electron and ions) are forced to flow in a closed annual path. As they meet resistance to their flow, heating takes place and additional ionization occurs. The process happens almost instantaneously, and the plasma expands to its full dimensions.

2.3 PE Optima 3000 DV:

The Perkin Elmer Optima 3000 DV ICP Optical Emission Spectrometer can view the plasma either axially or laterally (radially). The torch is positioned horizontally in the sample compartment along the central axis of the spectrometer optics. In this configuration, light emitted along the axis of the plasma is directed to the spectrometer optics. This increases the optical path length and the emission intensity seen by the instrument. See Figure 2.2

With the dual view configuration, a flow of shear gas (compressed air) is directed at the plasma to Ashear≅ of the tip of the plasma discharge. The shear gas

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minimizes the effects of self-absorption by forcing cooler atoms from the tip of the plasma out of the optical path. The shear gas also keeps the transfer optics cool. Figure 2-3 illustrates the shear gas effect.

2.4 Spectrometer Optics:

The optical system layout is shown in a flow diagram in Figure 2-4. The transfer optics of the Optima 3000 D.V. have been carefully designed to match the geometry of the axial view plasma. The observation zone of the plasma is circular; thus, the spectrometer looks down the bore of the axial view plasma and does not see as much of the background emission from the argon plasma.

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3.0 DEFINITIONS

3.1 Accuracy: Combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.

3.2 Analytical Batch: Samples which are analyzed together with the same method sequence and the same lots of reagents and with the same manipulations common to each sample within the same time period. The samples are of the same TYPE and the batch will be designated by sample type, protocol, revision#, year, the actual number of batches since the beginning of the current year, and sample collection beginning and ending dates. **A batch consist of 20 samples or less of the same WQL protocol.**

3.3 Background correction: Process of correcting the intensity recorded for a particular wavelength for intensity due to the ICP continuum background and other spectral interferences.

3.4 BEC test: Background Equivalent Concentration test. A test of instrument sensitivity. The concentration of a solution whose intensity is equivalent to the intensity of the background at the same wavelength is determined. The lower the concentration of this solution, the more sensitive the instrument for that element.

3.5 Calibration Blank (Cal Blk): A volume of reagent water acidified with the same acid matrix as in the calibration standards. The calibration blank is a zero standard and is used to auto-zero the instrument.

3.6 Continuing Calibration Verification Standard (CCVS): A mid-range ICAL standard used to verify continuing calibration. CCVS standards are used to verify instrument performance on a daily basis.

3.7 Control Charts: Charts used to maintain a current awareness of the accuracy/precision of each method and that the default acceptance criteria in the methods be updated to properly reflect the capability of the laboratory.

3.8 Correlation Coefficient (CC): Is a number in the range -1 through +1 that measures how closely the calculated line fits the data. All calibration curves must have a calculated CC of greater than or equal to 0.995.

3.9 Dissolved Analyte: The concentration of analyte in an aqueous sample that will pass through a 0.45 *u*m membrane filter.

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3.10 Field Duplicate (FD): A field duplicate sample that is exposed to sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the FD is to determine if method analytes or other interferences are present in the field.

3.11 Field Reagent Blank (FRB): An aliquot of reagent water or other blank matrix that is placed in a sample container in the laboratory and treated as a sample in all respects, including shipment to the sampling site, exposure to the sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the FRB is to determine if method analytes or other interferences are present in the field environment.

3.12 Initial Calibration Standard (ICAL): A solution prepared from the dilution of stock standard solutions. The ICAL solutions are used to calibrate the instrument response with respect to analyte concentration.

3.13 Initial Calibration Verification Standard (ICVS): A standard of known concentration obtained from an second source vendor, the same source but different lots, or the same lot prepared by a second analyst. ICVS standards are used to verify the calibration standards.

3.14 Instrument Detection Limit (IDL): The concentration equivalent to the analyte signal which is equal to three times the standard deviation of a series of ten replicate measurements of the calibration blank signal at the same wavelength.

3.15 Instrument Performance Check (IPC): A solution of method analytes, used to evaluate the performance of the instrument system with respect to a defined set of method criteria. A specific test to evaluate the performance of the instrument.

3.16 Interference: Anything that causes the analyte signal in a sample to be different from the analyte signal for the same analyte concentration in a calibration solution.

3.17 Laboratory Fortified Blank (LFB)=Laboratory Control Sample (LCS): A regent water blank to which known quantities of the method analytes are added in the laboratory. The LFB is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

3.18 Laboratory Duplicates (DUP): Two aliquot of the same sample taken in the

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laboratory and analyzed separately with identical procedures. The DUP indicates precision associated with laboratory procedures, but not with samples collection, preservation, or storage procedures.

3.19 **Laboratory Fortified Sample Matrix (LFM)=Matrix Spike (MS):** An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The LFM is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes positive or negative bias to the analytical results.

3.20 **Laboratory Fortified Sample Matrix Duplicate (LFM)=Matrix Spike Dup (MSD):** Two aliquot of the same sample taken in the laboratory and analyzed separately with identical procedures. Analyses of MS and MSD indicates precision associated with laboratory procedure.

3.21 **Laboratory Reagent (Method) Blank (LRB):** A reagent water blank carried through the entire analytical sample preparation procedure and is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and apparatus. The LRB is used to determine if method analytes or other interferences are present in the laboratory environment, the regents, or the apparatus.

3.22 **Linear Range:** The concentration range over which the analytical curve remains linear. Determined in the initial method development and performance demonstration.

3.23 **Method Detection Limit (MDL):** The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from an analysis of a sample in a given matrix containing the analyte.

3.24 **Nebulizer Flow:** The flow of argon gas that enters the nebulizer and carries the sample in the form of an aerosol into the plasma.

3.25 **Optimizing:** The process of determining the best conditions and settings for an analysis.

3.26 **Precision:** A measure of the degree of agreement among replicate analyses of a single sample or duplicate usually expressed as the standard deviation or % difference.

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3.27 **Proficiency Evaluation Samples (PE):** EPA water studies and in house quality control using secondary reference materials provided by QA Manger. The purpose of PE sample is to evaluate the laboratory performance and analyst performance.

3.28 **Quality Assurance:** A definite plan for laboratory operation that specifies the measures used to produce data of known precision.

3.29 **Quality Control:** Set of measures within a sample analysis methodology to assure that the process is in control.

3.30 **Spectral Interference:** An interference caused by the emission from elements or compounds other than those of interest.

3.31 **Spectral Interference Check (SIC) Solution**: A solution of selected method analytes of higher concentrations which is used to evaluate the procedural routine for correcting known interelement spectral interferences with respect to a defined set of method criteria.

3.32 **Stock Standard Solution:** A concentrated solution containing one or more method analytes prepared in the laboratory using standards purchased from a commercial source.

3.33 **Replicate:** Repeated operation occurring within an analytical procedure. Minimum of three data points for each method of analysis is required.

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4.0 INTERFERENCES

4.1 Spectral Interferences:
Light emission from spectral sources other than the element of interest may contribute to apparent net signal intensity. Sources of spectral interference include overlap of a spectral line from another element, unresolved overlap of molecular band spectra, background contribution from continuous or recombination phenomena, and background contribution from stray light from the line emission of high concentrations of elements. Avoid line overlaps by selecting alternate analytical wavelengths. Avoid or minimize other spectral interference by a background correct adjacent to the analytical line. A wavelength scan of the element line region is useful for detecting potential spectral interferences and for selecting positions for background correction.

4.2 Physical Interferences:
Physical interferences are generally considered to be effects associated with the sample nebulization and transport processes. Changes in properties such as viscosity and surface tension can cause significant inaccuracies, especially in samples which may contain high dissolved solids and/or acid concentrations. The use of a peristaltic pump can lessen these interferences. If these types of interferences are operative, they must be reduced by dilution of the sample and/or utilization of standard addition techniques. Another problem which can occur from high dissolved solids is salt buildup at the tip of the nebulizer. This affects aerosol flow rate and causes instrumental drift. Internal standards may also be used to compensate for physical interferences.

4.3 Chemical Interferences:
These interferences are characterized by molecular compound formation, ionization effects, and solute vaporization effects. Normally these effects are not significant. However, if observed, they can be minimized by careful selection of operating conditions (that is, incident power, observation position, and so forth), by buffering of the sample, matrix matching, and standard addition procedures. These types of interferences can be highly dependent on matrix type and the specific analyte element.

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5.0 SAFETY

5.1 Safety With ICP Source:

5.1.1 The Optima instrument is capable of generating lethal voltages. Therefore, no maintenance should be performed by anyone other than a Perkin-Elmer service specialist.

5.1.2 The Optima generates high levels of Radio Frequency (RF) energy, which is potentially hazardous if allowed to escape, The instrument is designed to contain the RF energy within the shielded enclosures of the sample compartment and the RF power supply. Safety interlocks prevent you from operating the system without all covers, doors, and shields in place.

5.1.3 The plasma torch generates high intensity ultraviolet energy. A safety interlock is used to automatically shut off the plasma if the sample compartment doors are opened. The sample compartment has a viewing window for safely viewing the plasma.

Caution: Directly viewing the plasma (without protection) may cause permanent impairment of eyesight.

5.1.4 The torch components and ceramic purge extension remain hot for some time after the plasma has been shut off. Allow sufficient time for these items to cool to room temperature before you handle them.

5.2 Handling Gases:

5.2.1 Gases used with Optima include argon and nitrogen. High pressure gas cylinders can be dangerous if mishandled. The following list includes general safe handling practices:

A) Read posted signs of "Safety Handling Of Gases" in the gas room.

B) Read Chemical Hygiene Policy for safe handling of gases and safe practices in the lab.

C) Move gas cylinders with an approved handcart after insuring that the valve cap is secured.

D) Store gas cylinders in a vertical position only.

E) Check ventilation in gas room.

F) When gas is delivered make sure gas cylinders are clearly marked and the

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appropriate gas is hooked-up to the appropriate regulator.

G) When equipment is turned off (at the end of the working day) close all gas cylinder valves tightly at the tank.

H) Perform periodic gas leak tests by applying a soap solution to all joints and seals to check for air bubbles.

I) Check gas gauges in spectrometer lab for a fall in pressure.

5.3 Drain Vessels:

The drain vessel system must be used for ICP operation. Improper assembly or maintenance may result in a serious explosion.

Follow the following suggestions:

A. Always place the drain vessel in an area that is visible to the operator, who can observe the level of collected effluent and empty the vessel when necessary.

B. Check the condition of the drain tubing regularly to monitor deterioration. When the tubing becomes brittle or cracked, replace it.

C. Empty the drain bottle regularly when using organic solvents. Before switching from organic to aqueous solutions, flush the drain tubing thoroughly and empty the drain bottle.

Never place the vessel in an enclosed cabinet. Doing so could result in a build-up of hazardous gases, which may result in a serious explosion or fire.

5.4 Exhaust Venting :

IMPORTANT: The plasma torch must be vented for proper operation of the spectrometer.

Exhaust venting of the Plasma Emission Spectrometer is important for the following reasons:

A. It will protect laboratory personnel from toxic vapors which may be produced by some samples.

B. It will improve the stability of the ICP torch and remove the effects of room drafts from the laboratory atmosphere.

C. It will help to protect the instrument form corrosive vapors which amy originate from the samples.

D. It will remove dissipated heat produced from the torch and power supply.

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5.5 Protective Equipment:

A. Wear appropriate eye protection at all times while handling chemicals. Use safety glasses in the laboratory area.

B. Wear suitable protective clothing, including lab coats and gloves specifically resistant to the chemicals being handled.

C. Use, store, and dispose of chemicals in accordance with WQL CHP policy.

D. Conduct sample preparation away from the instrument to minimize corrosion and contamination.

E. Clean up spills immediately using the appropriate equipment and supplies such as spill cleanup kits.

F. Store solvents in an approved cabinet away from the instrument.

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6.0 EQUIPMENT AND SUPPLIES

6.1 Optima 3000 DV Inductively Coupled Plasma Optical Emission Spectrometer: The Optima 3000 consists of two major components: the RF generator and spectrometer.

6.1.1 Spectrometer:

The Optima 3000 optical design combines an echelle polychromator with a solid state detector in an integrated system optimized for ICP-OES. The echelle polychromator covers the full ICP spectral range from 167 to 782 nm and produces a compact two-dimensional spectrum that is focused onto the solid-state detector. The Segmented-array Charged-couple device Detector (SCD) simultaneously measures emission lines for all ICP elements. The system also provides simultaneous coverage of background emission.

The Optima 3000 DV has two detectors - one detector for the ultraviolet range (167-375 nm) and one for the visible range (375-782nm) with one detector for each range. Dividing the range into two spectral regions utilizing two detectors provides a larger surface area than a single detector, which results in improved resolution. The use of two spectral regions also makes maximum usage of valuable detector area since the focal length of each range is matched to the detector size.

With the dual view configuration, a flow of shear gas (compressed air or nitrogen) is directed at the plasma to Ashear≅ off the tip of the plasma discharge. The shear gas minimizes the effects of self-absorption by forcing cooler atoms from the tip of the plasma out of the optical path. The shear gas flow is turned on automatically when the plasma is ignited. Observe the plasma by looking through the viewing window (at the mirror on the back wall of the sample compartment) to check that the shear gas is cutting off the tip of the plasma discharge. See Figure 2.3.

The entire optical system is enclosed in a purged and thermonstated optical enclosure.

Thermostating: The polychromator is thermostated to 38° C.

< Plasma Viewing: Viewing height change is accomplished by computer control of a mirror located in the optical path and allows viewing of the plasma source from the load coil to 30 mm above the load coil in 1 mm increments.

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< Shutter and Mercury Recalibration System: The pneumatically operated shutter automatically opens and closes for each sample. By closing the shutter between each sample, the first transfer mirror is protected from long exposures to the intense UV radiation of the plasma thus extending the useful lifetime of the mirror. The mercury emission line at 253 nm may be automatically monitored by the system and used to update the system wavelength calibration. Frequency of the automatic recalibration is user selectable and can vary between 3.000 minutes and 999 hours.

6.1.2. RF Generator:

The Optima 3000 uses a 40-MHZ free-running generator. In free-running generators, the actual frequency output changes slightly as the electrical characteristics of the plasma change to enable the most efficient coupling of the RF power to the plasma.

< The RF generator provides a power output of 750 to 1500 watts.

< The RF generator is designed with True Power Control (TPC), using a power control loop which maintains the plasma power setting regardless of line voltage fluctuations and changes in the plasma. See Figure 6.1.

6.2 Spectrometer Optics:

The optical system layout is shown in a flow diagram in Figure 2.4. The transfer optics of the Optima 3000 DV have been carefully designed to match the geometry of the axial view plasma. The observation zone of the plasma is circular; thus, the spectrometer looks down the bore of the axial view plasma and does not see as much of the background emission from the argon plasma.

The computer-controlled mirror controls the viewing height in the lateral mode and the viewing (torch) alignment in both modes.

6.3 Sample Introduction:

6.3.1 Spray Chamber and Nebulizer:

A Scott double-pass spray chamber designed to minimize pulsations from the peristaltic pump and constructed of Ryton for complete corrosion resistance.

< Gem Tip Cross-Flow pneumatic nebulizer are the standard components supplied with the Optima 3000 DV. Other nebulizers include the High Solids Conespray

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nebulizer for samples with high solids concentration and the Low Flow Conespray nebulizer for lower nebulizer gas flow rates.

6.3.2 Plasma Torch:

The torch has a standard alumina injector (full corrosion resistance to all acids) with a 2.0 mm inner diameter. The torch glassware is slotted so the plasma is viewed optically through the slot and not the quartz, for best performance while maintaining optimum shielding of the plasma from entrained air.

6.3.3 Peristaltic Pump:

The Perkin Elmer AS-91 autosample consist of sample table, a sample tray, and a motorized sampling arm with an attached probe. Speed is variable from 0.2 to 2.5 mL/minute in 0.1 mL/minute increments using 0.76 tubing. The peristaltic pump is fully computer-controlled.

6.4 Cooling Water:

A water supply is required to dissipate heat from the RF coil and the detectors.

< A Neslab CFT-33 Recirculating Chiller is used instead of a cooling water supply (non-recirculating). The requirements for the chiller are:

< Cooling Capacity at 20C	950 watts
< Temperature Stability	+/- 1C
< Pump Rate	1 gal/min at 60 psi max

6.5 Exhaust Vents:

The Optima 3000 requires two exhaust vents:

< An exhaust vent for the ICP torch to remove combustion fumes and vapors from the torch housing. Maximum ICP torch vent temperature specification is 200C.

< An exhaust vent to remove dissipated heat from the RF power supply. Maximum RF vent temperature specification is 80C.

6.6 Pneumatic Requirements:

6.6.1 Argon Supply:

Available argon pressure should be between 490 to 825 kPa (70-120 psig). The argon flow for the system may vary between 1 and 25 L/min. A tank of liquid argon containing 160 liters will typically last 80 hours of continuous running time.

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6.6.2 Nitrogen Supply:

Nitrogen is required to purge the spectrometer optics. The spectrometer typically consumes nitrogen at a rate of 1-5 L/min. Available nitrogen pressure should be between 200 and 825 kPa (30-120 psig).

6.6.3 Shear Gas:

The Optima 3000 require a supply of shear gas. The shear gas used is typically compressed air.

6.7 ICP WinLab:

< Operation is simplified. Based on the familiar Microsoft Windows menus and graphics, the software has easy-to-use graphics and familiar pull-down menus.

< Comprehensive data reprocessing and reporting capabilities include: built-in QC automation routines; full data reprocessing from stored spectra; methods and data stored in a commercial database; and easy generation of customized reports using off-the-shelf word processor or spreadsheet program.

6.7.1 Library Manager:

Lets you archive, copy, delete, and rename the data sets created by ICP WinLab.

6.7.2 Reformat Data:

Lets you select a subset of the data contained in a results data set and write it into a reformatted file that can be read by many off-the-shelf applications, including spreadsheet and database management.

6.7.3 Reporter:

Lets you control the design of and the information included in the report.

6.7.4 Windows screen capture programs:

Lets you capture any screen in th ICP WinLab software.

6.7.5 Window Categories:

This table lists the function of each group of windows.

Window Function	Window Name
Specialized editors for parameter input	Method Editor, Sample Information Editor

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Windows for information display	Examine Spectra window, Spectra Display window, Results Display window, Analytical Sequence window
Windows for controlling analyses	Manual Analysis Control window, Automated Analysis Control window, Data Reprocessing window
Windows for controlling the instrument and accessories	Plasma Control window, Spectrometer Control window
Windows to make corrections for interferences	Interelement Correction window, Multicomponent Spectral Fitting window

7.0 REAGENTS AND STANDARDS:

7.1 Argon:
A supply of argon meeting the purity criteria of ∃ 99.996%.

7.2 Nitrogen:
A supply of nitrogen meeting the purity criteria of ∃ 99.999%.

7.3 1% HNO3:
Prepare using 100mls Ultrapure HNO3, diluting to a volume of 10,000 mls with deionized/reverse osmosis water which is prepared by passing distilled water through a mixed bed of cation and anion exchange resins. Use 1% HNO3 for the preparation of all reagents, calibration standards and as dilution water. Also use for rinse samples during analysis, Auto Zero blank sample, and rinse vessel.

7.4 MnBEC 1ppm:
Prepare using 0.50 mL of PEN930-0281 to 50mL 1% HNO3.

7.5 Initial Calibration Standards (ICAL):
Prepare a series of standard metal solutions in concentration ranges listed below. Perkin Elmer or RICCA standards are used as primary standards and JT Baker as secondary standards. See Standard Logbook for specific directions.

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A.) Ca/Na/K/Mg
S1- 10 ppm Ca/Na
2 ppm K/Mg
S2- 50 ppm Ca/Na
10 ppm K/Mg
S3-100 ppm Ca/Na
20 ppm K/Mg

B.) Al/B/Be/Mo
S1-500 ppb
S2- 2500 ppb
S3- 5000 ppb

C.) Co/Cu/Fe/Mn/Ni/Sr/V/Zn
S1- 500 ppb
S2- 2500 ppb
S3-5000 ppb

D.) ~~Si-SiO2~~
S1-10.7 ppm
S2- 53.5 ppm
S3- 107 ppm

E.) Ag/Ba/Li
S1- 500 ppb
S2- 2500 ppb
S3- 5000 ppb

For preparation follow the method outlined in the **Plasma Optima Laboratory Standard Logbook** and always follow the C1V1=C2V2 formula. All standards will be prepared every two weeks. Follow proper procedures for recording in Laboratory Standard Book.

7.4 Initial Calibration Verification Standard (ICVS):
A Quality Assurance sample will be run at the beginning of each batch. The ICVS sample should be midrange of the calibration curve. Also, the ICVS samples

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should be prepared using a supply from a second vendor, same vendor different lot, or prepared by a different analyst.

A.) Ca/K/Mg/Na
B.) Al/Mo/Ba/Be/Co/Cr/Cu/Fe/Mn/Ni/V/Zn/Li/Sr
C.) SI-SIO2
D.) Ag

7.5 Continuing Calibration Verification Standard (CCVS):
All S2 standards will be used to verify instrument performance.

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