

# BUCK SCIENTIFIC

ATOMIC ABSORPTION SPECTROPHOTOMETER

MODEL 225/23x SERIES



OPERATOR'S MANUAL

Rev. A6.1





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# **Buck Model 225/23x Series Atomic Absorption Spectrophotometer**

## ***INTRODUCTION***

The Buck 200 series atomic absorption spectrophotometer is designed to measure the concentration of elemental (ionic) metals in solution. It performs integrated measurements in absorbance or emission intensity, as well as sample concentration in comparison to standard solutions. The readings can be integrated over a period from 0.1 to 99.9 seconds. For the transient signals obtained using flame-less techniques (cold vapor, hydride, and graphite furnace) peak height or peak area integrations are provided.

The Buck 200 series can be calibrated using up to 9 concentration values, with units of *mg/L*, *µg/L*, *ppm*, *ppb*, *mEq/dL*, *mM/dL*, *µg/dL*, *%* or any *user defined unit*. Calculations can be performed using linear regression, first, second and third order curves. Report functions allow the user to print absorbance data, background absorbance and concentrations, and to collect absorbance values using a laboratory recorder.

## ***SAFETY***

The methods and analytical procedures described in this manual are designed to be carried out by properly trained personnel in a suitably equipped laboratory. In common with many laboratory procedures, the methods described may involve hazardous materials or substances of unknown toxicity. For the correct and safe execution of the methods, it is essential that laboratory personnel follow standard safety procedures for the handling of hazardous materials.

While the greatest care has been exercised in the preparation of this information, Buck Scientific, Inc. expressly disclaims any liability to users of the procedures for consequential damages of any kind arising out of or connected with the use of these procedures.

For specific safety information, refer to the OSHA documentation on hazardous materials handling and procedures, and consult the Material Safety Data Sheet (MSDS) for the chemicals with which you are working. By law, MSDS sheets must be made available by the company which manufactures the chemicals you are using.

Neither this entire manual nor any part of it may be reproduced without the expressed consent of Buck Scientific, Inc.

Direct all inquiries regarding this manual and/or the 200 Series Atomic Absorption Spectrophotometer to your Buck Scientific Sales Representative or to:

Buck Scientific Inc.  
58 Fort Point Street  
Norwalk, CT 06855

Tel: 203-853-9444 or 800-562-5566  
Fax: 203-853-0569  
E-mail: [sales@bucksci.com](mailto:sales@bucksci.com)

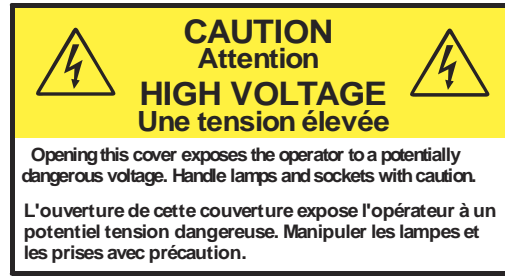
***Please Note: If the 200 series AA is used in a manner not specified by Buck Scientific Inc., the protection provided by the 200 series AA may be impaired.***

*Important Warning and information labels*

High Voltage warning:

The label attached to the lamp turret access door indicates the presents of high voltages associated with the lamps and sockets.

This warning also applies to removal of the lamp access cover at the end of the instrument.



High Temperature warning:

The high temperature label in the sample compartment is associated with the operation of the burner head.



Air/fuel limits label:

The inlet pressures limits label on the back of the 200 series AA inicates strict limits to input gasses and air for proper and safe operation.

Air/Fuel Inlet Limits Air/carburant limites Inlet	
Air :	55 to 100 psi 55 À 100 lb/po2
Acetylene:	12 to 15 psi
Acétylène:	12 À 15 lb/po2
Nitrous:	50 to 100 psi
Nitreux:	50 À 100 lb/po2

Flamable Gas warning:

This label indicates the use of flammable gases in the operation of the instrument.





## SECTION 1.1: General Specifications

**Electrical:** *Auto selectable 100V to 230V 50/60Hz input  
Power Consumption: .5 A*

**Optics:**

*Detector: model 928; wide range general purpose, 190-930nm  
Optional Detectors: model 955; UV enhanced, wide-range, 190-930nm  
Lenses: Supracil - amorphous silica  
Monochromator: 0.25m Ebert mount  
Grating: 32nm x 27nm; 600 grooves/mm  
Wavelength adjustment: 3 digit motor driven, 0 to 1000nm  $\pm 0.1$  nm  
Reproducibility:  $\pm 0.1$  nm  
Resolution: variable slit - 2Å, 7Å, and 20Å*

**Operating Modes:**

*Absorbance/Emission: -0.0820 to 3.2000  
Concentration: to 5 significant digits  
Integration Period: 0.1 to 99.9 seconds  
Screen Refresh : 0.224, 0.448 or 0.896 seconds  
Recorder Output: 1V/ABS (-0.08 to 3.2V)  
Background Correction: In-line Deuterium Arc*

**Hollow Cathode Lamps:**

*Dimension: 1.5" OD  
Striking Voltage: 500V  
Lamp Current: 0 to 18 mA average current (typical current is 1.5-8.0 mA)  
Duty Cycle: 25%  
Modulation Frequency: (142 Hz Nominal)*

**Burner Assembly:**

*Design: Polyethylene Pre-mix chamber, glass impact bead dispersion  
Burner Head: Titanium; air-acetylene head - 4" x 0.026" single slot  
(nitrous oxide head - 2" x 0.019" single slot)  
Adjustments: Horizontal and Vertical positioning*

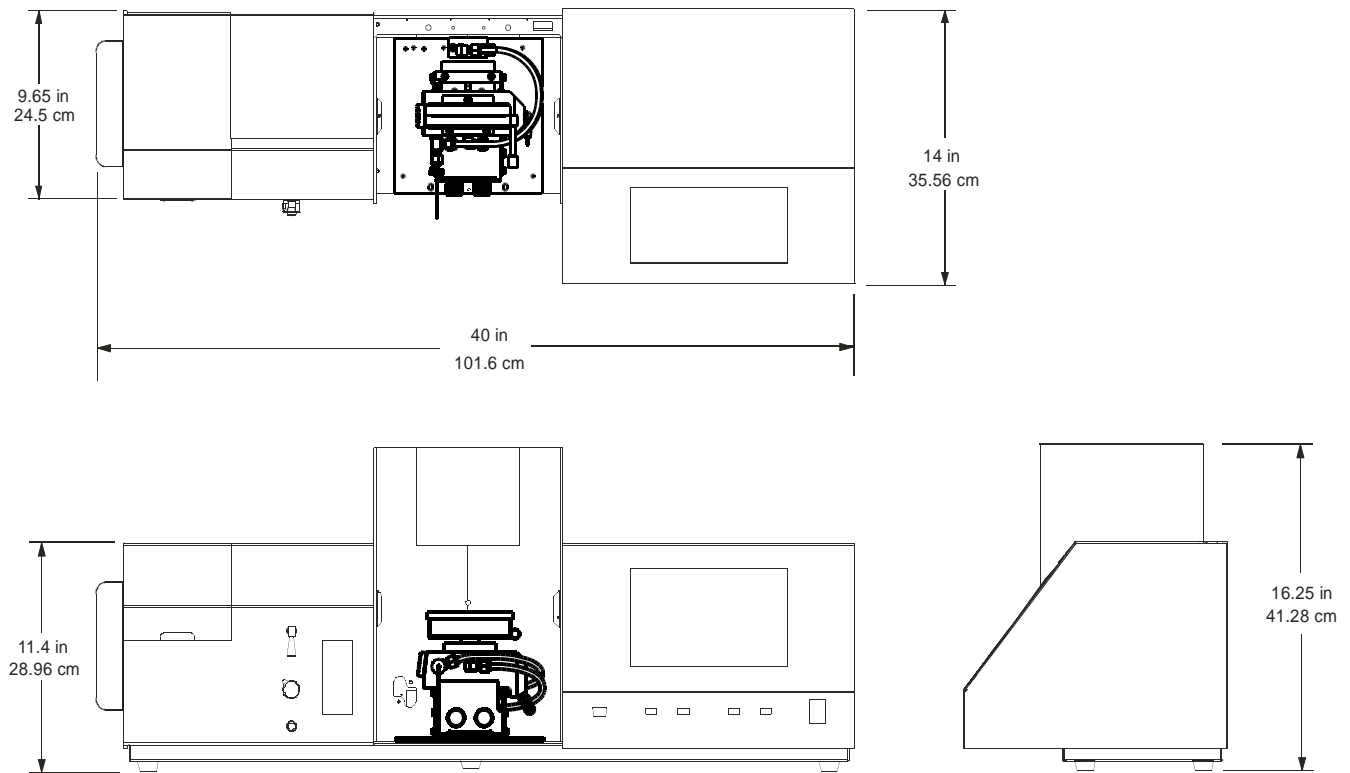
**Performance:**

*Average Noise (at  $3\sigma$ ): 0.0018 ABS (Cu at 324.7nm, 7Å slit, 5 sec. int.)  
Sensitivity: see specific element chart (Sect. 4)  
Reproducibility:  $\leq +5\%$  relative standard deviation*

**Mechanical:**

*Continued next page....*

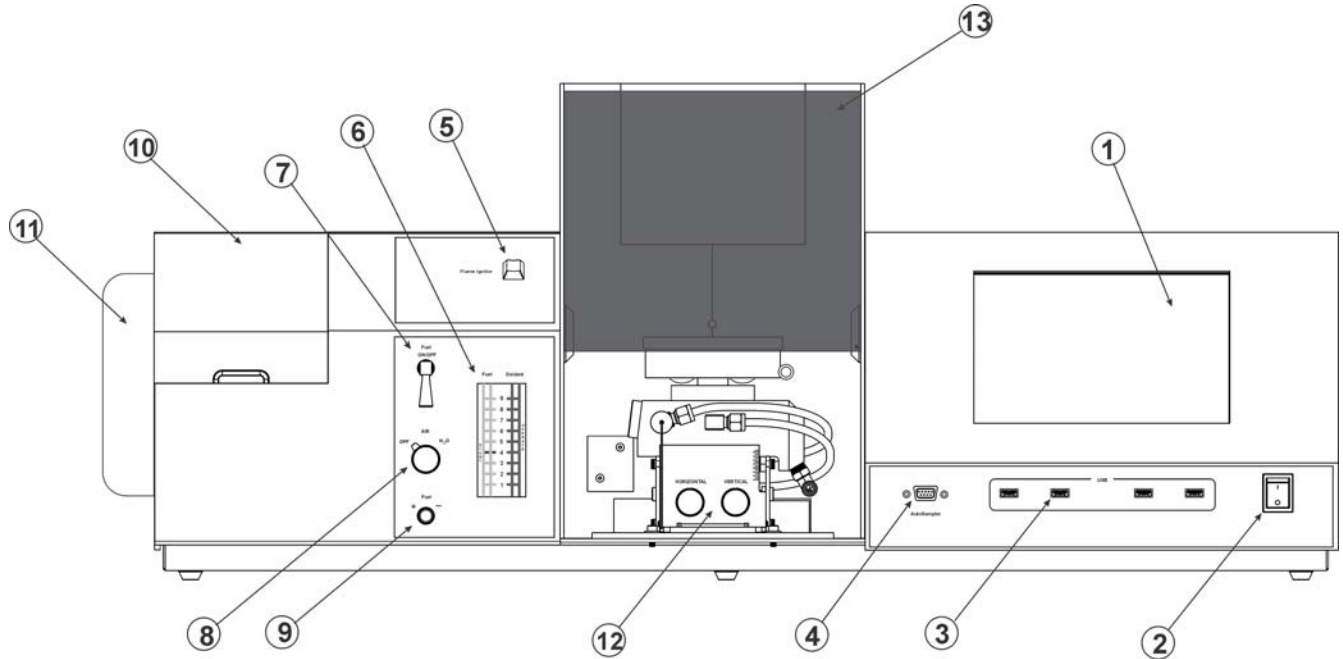
***Dimensions:***



***Weight: 70 lbs ( 26.13 kg )***

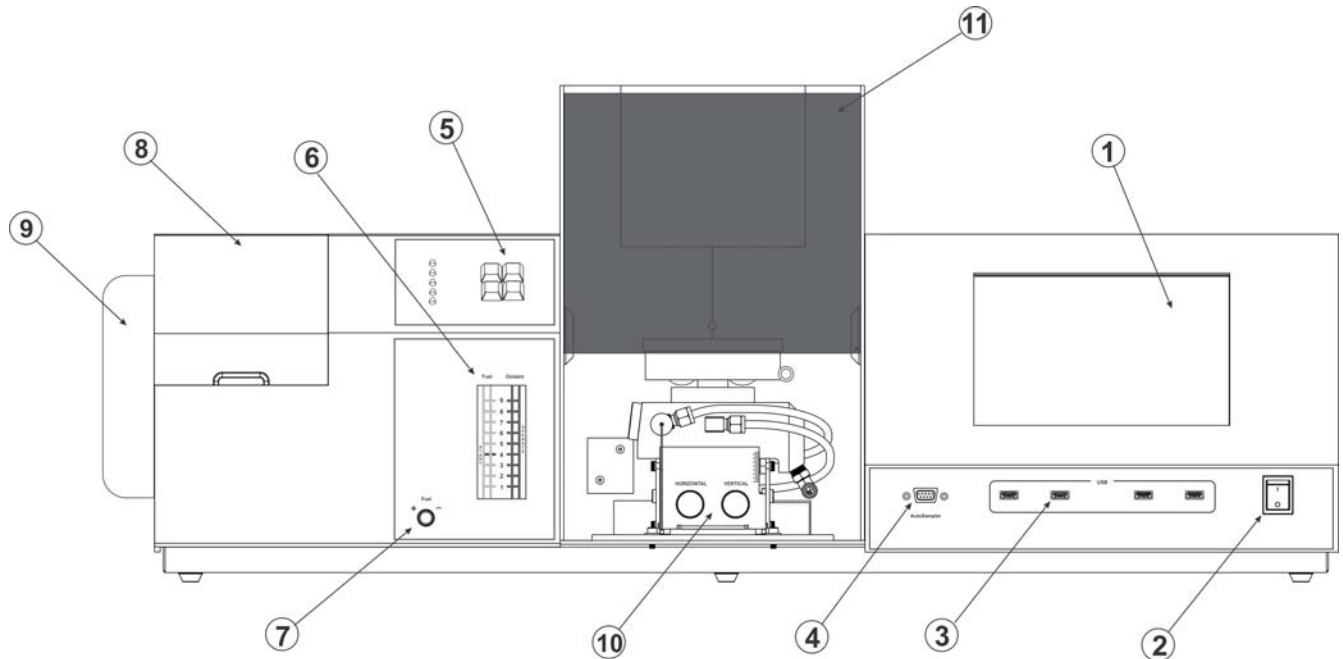
***Environment: Temperature, 50° - 90°F ( 10° to 32°C )***  
***Relative humidity, 30% to 80% non condensing.***

# 225/230 Front View



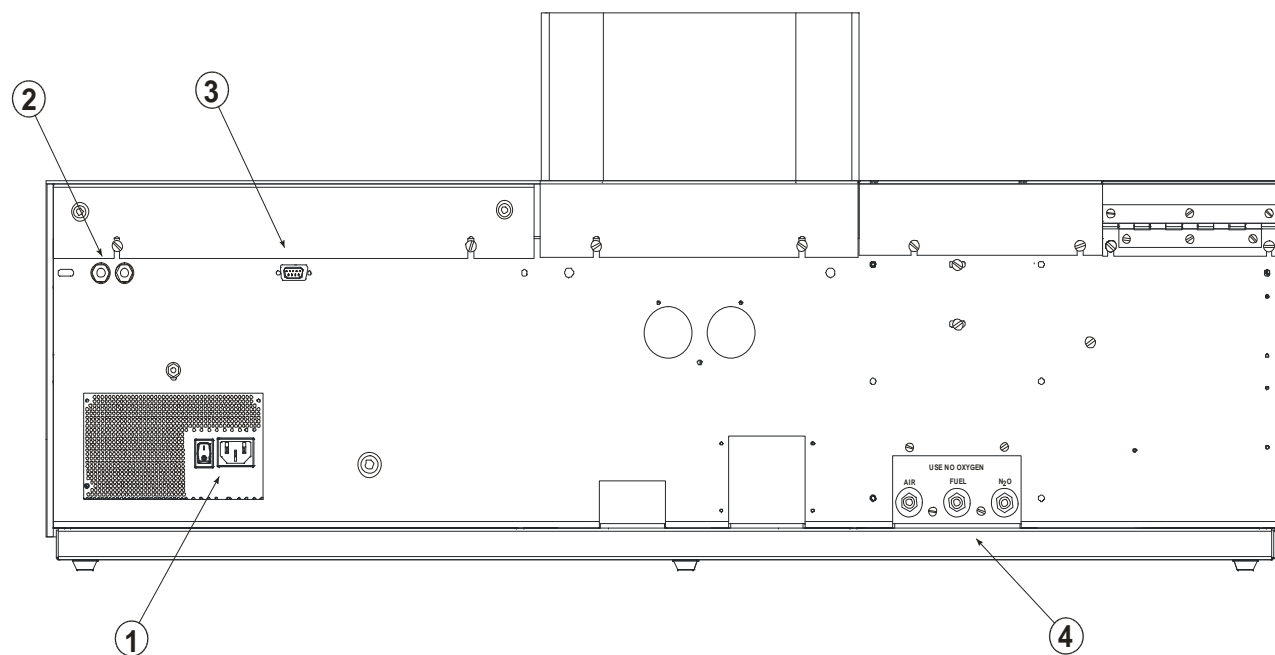
- 1.** Touch panel display
- 2.** Power switch
- 3.** USB ports
- 4.** Autosampler interface
- 5.** Ignitor Button
- 6.** Flow indicator
- 7.** Fuel toggle valve
- 8.** Oxidant selector
- 9.** Fuel adjust
- 10.** Lamp turret door
- 11.** Lamp access cover ( 230 only )
- 12.** X-Y table horizontal and vertical adjustments
- 13.** Flame safety shield

# 235 Front View



1. Touch panel display
2. Power switch
3. USB ports
4. Autosampler interface
5. Auto gas box controls
6. Flow indicator
7. Fuel adjust
8. Lamp turret door
9. Lamp access cover
10. X-Y table horizontal and vertical adjustments
11. Flame safety shield

## 225/230/235 Rear View



1. Power supply
2. Analog output (1V/1Abs.)
3. Graphite furnace connection
4. Gas Inlets

## SECTION 1.2: Unpacking the 200 series AA

When unpacking the 200 series AA, check for any shipping damage or missing items.

The installation kit should compose of:

Part number	Description	Quantity
230-1070	Safety shield	1
999-2202	Slot cleaner/gap checker	1
999-3127	3/16 Hex driver	1
999-3123	5/32 Hex driver	1
991-1073	1/16 Hex Key	1
BS30040	0.5 Absorption screen	1
BS303-0135	Nebulizer cleaning wire	10
990-8265	Nebulizer tubing	10 ft ( 304.8 cm )
990-1536	Burner o-ring	1
990-3083	Blow out plug o-ring	1
990-1531	X-Y table o-ring	3
990-1856	1/4" Red tubing	10 ft ( 304.8 cm )
990-1855	1/4" Black tubing	10 ft ( 304.8 cm )
990-1857	1/4" Blue tubing	10 ft ( 304.8 cm )
BS250-6519	1/2" PVC Drain tubing	6 ft ( 183 cm )
990-1072	Power cord	1
991-1074	Stylus w. holder	1
991-1075	USB Keyboard	1
991-1076	USB Mouse	1



The 200 series AA weights 70 pounds ( 31.8 kg ) and should be removed from the shipping box by two people.

Once the top foam packaging is removed, the instrument can be lifted out by holding each end of the 230 AA and carefully lifting it out of the shipping container.

Retain the shipping container for future shipping.

## SECTION 1.3: Installation - Gas Supplies

**GAS SUPPLIES:** (This material was extracted from uncopywrited information provided by the Scientific Apparatus Makers Association, No. AI 2.1)

### **Acetylene:**

For the majority of analysis, commonly available welder's grade acetylene is the required fuel for use with the model 2xx AA. Acetylene is usually obtained in size 1B cylinders containing about 9000 liters (at STP) of gas dissolved in acetone. An air-acetylene flame consumes about 5 liters per minute, whereas a nitrous oxide-acetylene flame consumes about 15 liters per minute. Consequently, a single 1B cylinder will give from 10 to 30 hours of operation, depending on the amount of N<sub>2</sub>O to air used. Acetylene cylinders utilize a CGA510 two-stage regulator with a flash arrestor (part no. 6103A).

Acetylene is dissolved in acetone in order to prevent explosive decomposition when compressed to greater than about 30 psi. To provide a margin of safety, acetylene should not be used above 15 psi line pressure. As acetylene is removed from the cylinder, acetone vapors accompany it in increasing proportion as tank pressure falls. Since acetylene is in solution, the pressure drop is not linear, and a pressure of 75 psi indicates a nearly empty tank. For some elements, absorption sensitivity will change as the amount of acetone increases, so it is a good practice to replace the cylinder when the pressure falls to between 75 and 100 psi. Running the instrument with the pressure below 75 psi may result in acetone getting into the instrument and damaging flow meters or gas controls.

**Special Cautions:** Acetylene forms unstable acetylides if it comes in contact with copper, silver or mercury. Wet acetylene forms explosive acetylides with copper. The rate of acetylide formation increases in the presence of air or carbon dioxide. ***Pure copper should never be used for acetylene plumbing.*** Acetylides are formed much less rapidly on brass than copper.

### **Hydrogen:**

In certain applications hydrogen is used as the fuel, usually obtained in 1A cylinders containing about 5500 liters (at STP). The extra dry grade (99.9+% purity) is suitable for atomic absorption work. An air-hydrogen flame requires about 15 liters per minute, which represents about 6 hours of operation for a 1A cylinder. The air-hydrogen flame is invisible under normal circumstances, and extra caution should be exercised when using this flame. Do not place hand on or lean over a burner where hydrogen is being used in case the flame is actually lit. Always test first by placing a shiny surface above the region of combustion; the formation of water vapor indicates that the flame is lit. Hydrogen cylinders are used at high pressure and should be handled with care at all times. They are operated at 40psi using a CGA350 two-stage regulator.

### **Air:**

Air is the most common oxidant and can be obtained from either a compressed air cylinder or from a compressor unit. A standard 1A air cylinder contains about 6200 liters (at STP). The 200 series AA premix burner-nebulizer will use about 20 liters per minute, and therefore one cylinder will last about five hours. Occasionally cylinder air has gone through a liquification stage during which the oxygen to nitrogen ratio can change, and it is not uncommon to find other than 20% oxygen in air cylinders. This can be a potential safety hazard, and cause variable burner performance and analytical results. Medical grade or Breathing Air is often compounded from Nitrogen and Oxygen to contain greater than the

## **SECTION 1.3: Installation - Gas Supplies (cont.)**

normal Oxygen content of Air and are not recommended. General Purpose Compressed Air is suitable for instrument use. Air cylinders are operated at 50psi utilizing a CGA590 two-stage regulator.

Because of the limitations inherent in using compressed air cylinders, an oil-less air compressor is usually used. The compressor should provide at least 30 liters per minute at 50 psi, with a water and oil trap installed between the compressor and the 2xx AA. Buck Scientific supplies a suitable compressor (part no. BS303-0313) and filter assembly (part no. BS303-0229).

### ***Nitrous Oxide:***

Nitrous Oxide is usually obtained in 1A cylinders containing about 15,000 liters (at STP). The N<sub>2</sub>O is in the liquid state, at an initial pressure of about 750 psi. Because of this, the pressure gauge does not indicate how much liquid remains until the pressure starts to fall off rapidly as residual gas is withdrawn. A nitrous oxide-acetylene flame consumes about 20 liters per minute of N<sub>2</sub>O at 50 psi; therefore a single 1A cylinder will last about 12 hours.

When N<sub>2</sub>O is removed from the cylinder at this rate the expanding gas cools the diaphragm of the regulator so that sometimes it freezes, causing loss of regulation. It is therefore advisable to use a Ambient Air Heated Regulator. All lines carrying N<sub>2</sub>O should be free of grease, oil or other organic material, as it is possible for spontaneous combustion to occur. Cylinders of N<sub>2</sub>O should be considered high pressure cylinders and handled with care at all times.

### ***Argon:***

Argon is usually obtained in size 1A cylinders containing about 7000 liters (at STP). It is used with a CGA580 two-stage regulator. Argon is generally used in conjunction with hydrogen as a flame diluent to provide a cool flame, as a purge gas in the analysis of hydride-forming metals, and also as a sheathing gas in graphite furnace work. Consequently the consumption rate varies widely, depending on the particular application. High purity grade (99.995%) Grade Argon is good for most analyses. Argon in the pre-purified grade (99.998%) can also be used but is not recommended for the Graphite Furnace since the grade often contains a small amount of oxygen which may shorten tube life. Argon cylinders are used at high pressure and should be handled with care at all times.

### ***Nitrogen:***

Nitrogen is usually obtained in size 1A cylinders containing about 6500 liters (at STP). It is used with a CGA580 two-stage regulator. Nitrogen is used similarly to argon, and therefore the consumption rates vary widely with the application. The high purity grade (99.9%) or the extra dry grade (99.7%) is suitable for atomic absorption work. Nitrogen cylinders are used at high pressure and should be handled with care at all times.



## SECTION 1.4: Installation - Preparing the Lab

This section gives details concerning the space and accessories required to set-up the Buck 2xx atomic absorption spectrophotometer.

### *Equipment to be Provided by the Analyst*

The following lists the equipment and materials that you will need to operate the 2xx AA. Many of these materials may have been supplied as options with your 2xx AA. They can also be purchased from your Buck Scientific Sales Representative, and are shown with part numbers for your convenience.

1. Exhaust Vent (part # BS303-0407).
2. Standards, matrix modifiers & acids for the elements to be determined.
3. One (110/120 v-15 amp) outlet for instrument. Add one outlet each if you will be using a printer, computer and autosampler.
4. Distilled or deionized water.
5. 3' X 5' lab bench area.
6. Drain Vessels for Waste fluids (no glass).
7. Hollow Cathode Lamps for elements to be determined (*see catalog for part #'s*).

### *For flame analysis...*

1. Size 1A compressed air cylinder (General Purpose) & regulator CGA-590 (part # BS303-0264) **or** oil-less air compressor (part # BS303-0313) & filter assy (part # BS303-0229)
2. Size 1B acetylene cylinder (welding grade) & two stage regulator CGA-510 (part # BS303-0106)
3. Flash arrestor for acetylene tank (part # 6103A). Check with local Fire Code for requirement.
4. Size 1A nitrous oxide cylinder (if you will be doing N2O determinations) & Ambient-Air heated regulator.

### *For flame hydride analysis...*

1. Size 1A hydrogen cylinder & regulator CGA-350 (part # BS303-0265).
2. Size 1A argon (or nitrogen) cylinder & regulator CGA-580 (part # BS303-0264).

**Note:** *All regulators must be ready to accept a 1/4" swagelock nut for installation.*

### *Instrument Grounding...*



The 2xx AA must be provided a proper ground through the power cord.  
Check outlets prior to installation for proper grounds.  
The operator must correct any grounding issues before operation.

## SECTION 1.5: Installation - Basic Instrument and Flame

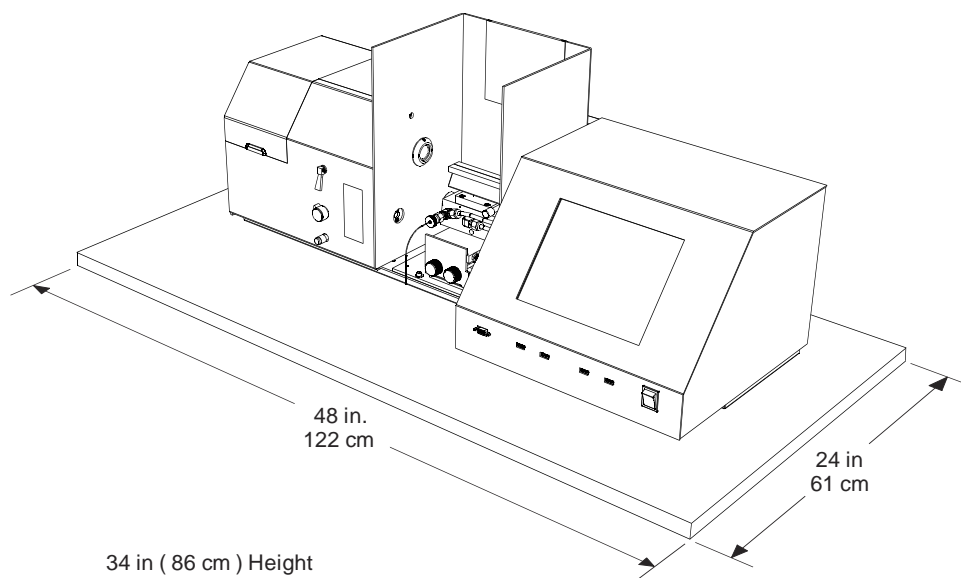
### *Suitable Work Area*

For best performance, the 2xx AA should be located in a well-ventilated room, free of dust, draughts, and corrosive fumes and vapors. Because it must be vented through an exhaust duct, it is best to locate the instrument near an external wall, or close to other duct lines that are used for similar purposes. It is sometimes possible to tie the exhaust vent into a laboratory fume hood exhaust line. A backflow preventer should be installed between the 2xx AA exhaust line and the fume hood line to prevent cross-contamination.

Locate the spectrophotometer on a workbench or table large enough to accommodate the instrument, samples and all accessories. The recommended dimensions are shown in the diagram below. The workstation should be flat, sturdy and free of vibration.

Minimum Rear Clearance to back splash or wall: 4" (*Proper distance from the back of the instrument to any obstruction must be maintained so that the power cable or gas lines can be quickly accessed in an emergency*).

Minimum recommended Table Dimensions:



The laboratory environment should be regulated to provide stable temperature and humidity. The 200 series AA should be maintained at temperatures from 10° to 32°C (50° - 90°F), and relative humidity of 30% to 80% noncondensing.

In many applications data handling may be accomplished using an external printer or a laboratory chart recorder. These accessories should be located near the instrument for easy access. It is advisable to place the printer or recorder on a separate workbench or table on the right hand side of the 2xx AA, since the external connections are made on that side of the instrument. This will prevent the cables from having to cross over the gas lines, and make them more accessible.

## SECTION 1.5: Installation - Basic Instrument and Flame (cont.)

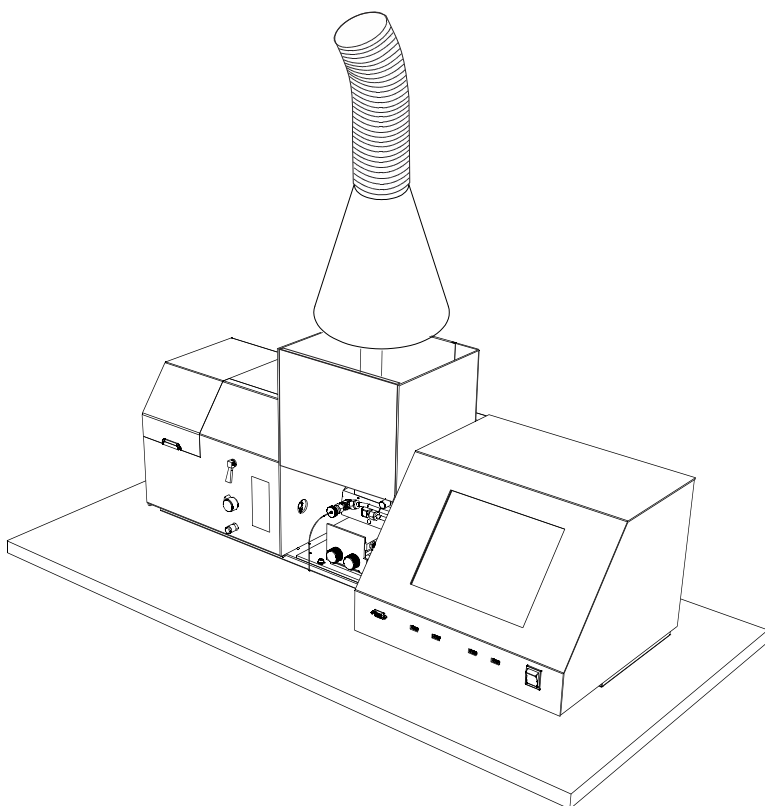
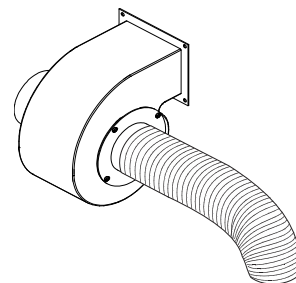
### Ventilation

The combustion of metallic and organic compounds can produce toxic vapors, as well as extreme heat. In order to protect the analyst and maintain a safe, clean laboratory environment, a permanent vent should be installed. The ventilation system must meet the specifications listed in Table 1 below.

**Table 1: Exhaust Ventilation System Specifications**

<b>Exhaust Manifold:</b>	Stainless Steel Cone 8" x 12" opening tapering to a 4" collar, 12" overall length.
<b>Manifold Installation:</b>	Directly above combustion chamber at a height of 18" to 22" above the bench.
<b>Primary Exhaust Duct:</b>	4" diameter flexible stainless steel.
<b>Secondary Exhaust Duct:</b>	6" diameter minimum dimension.
<b>Blower Capacity:</b>	300 cubic feet per minute.
<b>Blower Installation:</b>	Minimum 10 feet from manifold.

Install the blower motor so that exhaust exits to the outside.



Install the hood so that it is directly over the burner head and 6 to 8 inches above the top of the 200 series AA.

## SECTION 1.5: Installation - Basic Instrument and Flame (cont.)

### INSTALLATION

#### Gas Connections

Using the 1/4" brass fittings, connect the BLACK nylon hose from the Air supply to the AIR port (black fitting) on the back of the 2xx AA. Connect the RED hose from the Acetylene tank to the C<sub>2</sub>H<sub>2</sub> port (red fitting). If using Nitrous Oxide connect the BLUE hose from the Nitrous Oxide tank to the N<sub>2</sub>O port (blue fitting). Tighten all fittings 1/4 turn past finger tight to insure a good seal.

#### Electrical Connections

Plug the power cord into a standard AC grounded outlet and connect the other end to the power adapter on the back of the 2xx AA.

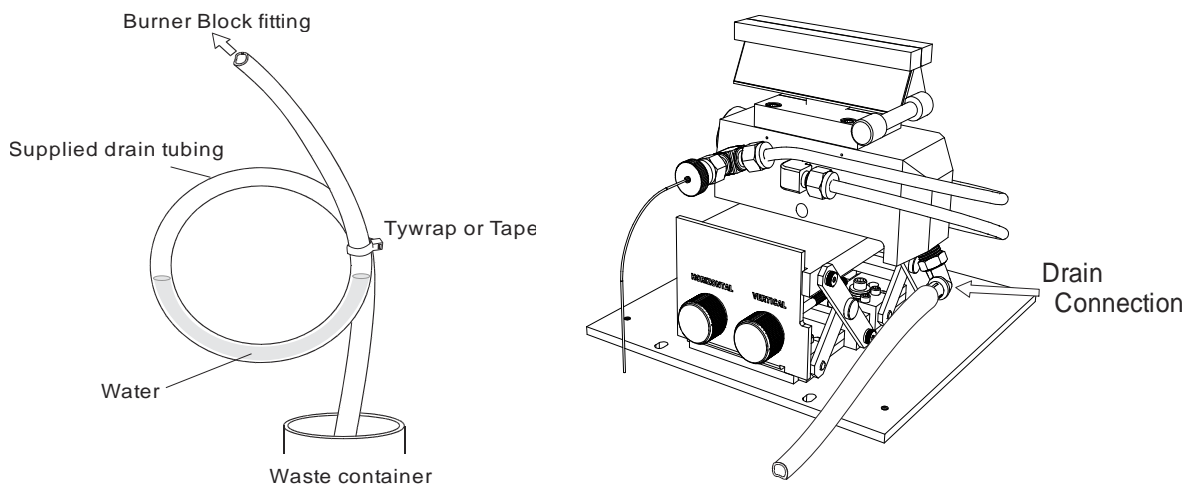
#### Drain Line

Connect the 3/8" clear Tygon tubing to the black plastic Drain port on the 2xx AA burner assembly. Form a 8" loop in the tubing just below the level of the instrument, and secure it with cable tie or tape. Fill the loop with water using a wash bottle before you have connected it to the drain block, or more conveniently with the drain tube connected, turn on the air only at the instrument & aspirate water through the burner for a while. Place the other end in a large (1 gallon or more) **Plastic** jug, *do not use glass*, making sure the tubing is ABOVE the level of the waste liquid, and secure in place with tape or twist ties.

**Danger:** The water loop acts as a vapor trap to prevent combustible gas mixtures from entering the waste container. If this should happen a potentially hazardous condition would exist.

**Flash backs can occur from the burner head if the combustion mixture is made too lean.** This is especially true when using nitrous oxide. If the loop is empty a flash back can explode into the waste container, causing severe damage to equipment and may injure personnel.

**NOTE:** When using organic solvents (i.e., MEK, MIBK) for concentration/extraction purposes always flush the drain line with water after analyses are completed. Otherwise a **flashback** can explode in the loop itself.

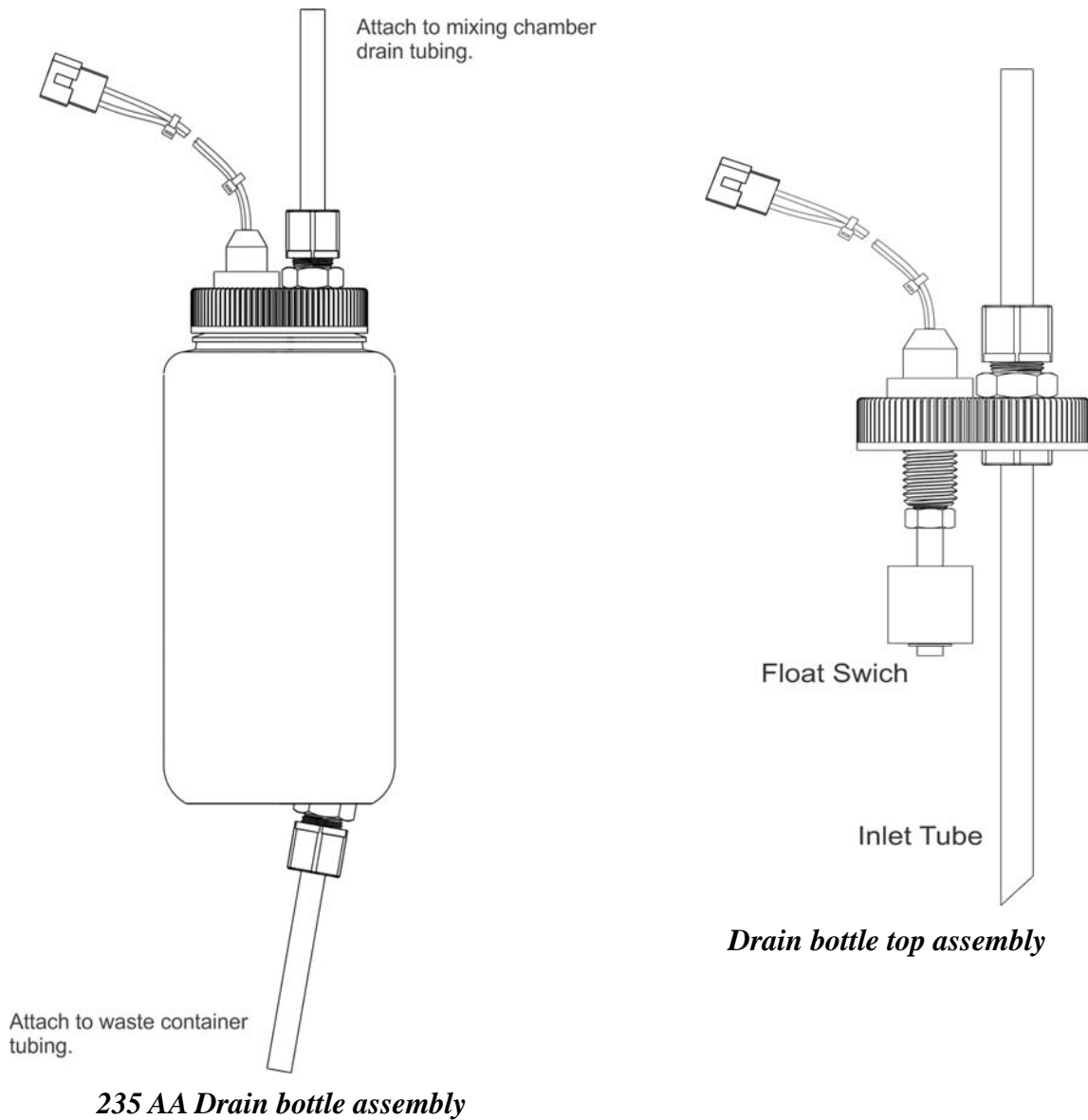


### **235 Drain Bottle**

The drain collection from the mixing chamber on the 235 AA instrument uses a drain bottle that substitutes for the drain loop on the 225/230 AA models.

The bottle incorporates a flow level switch that will signal the 235 AA that the fluid level is too low.

Refer to section 2.4 for more information on the drain bottle hookup and operation.



## SECTION 2.1: Instrument Operation-Preparing the Instrument

### *Setting the instrument time:*

To set the instrument time clock, first exit the 2xx AA user interface and access the Linux operating system by pressing Alt-F4 on the keyboard.

Move the cursor to the bottom of the screen, and the taskbar should pop up from the bottom of the screen.

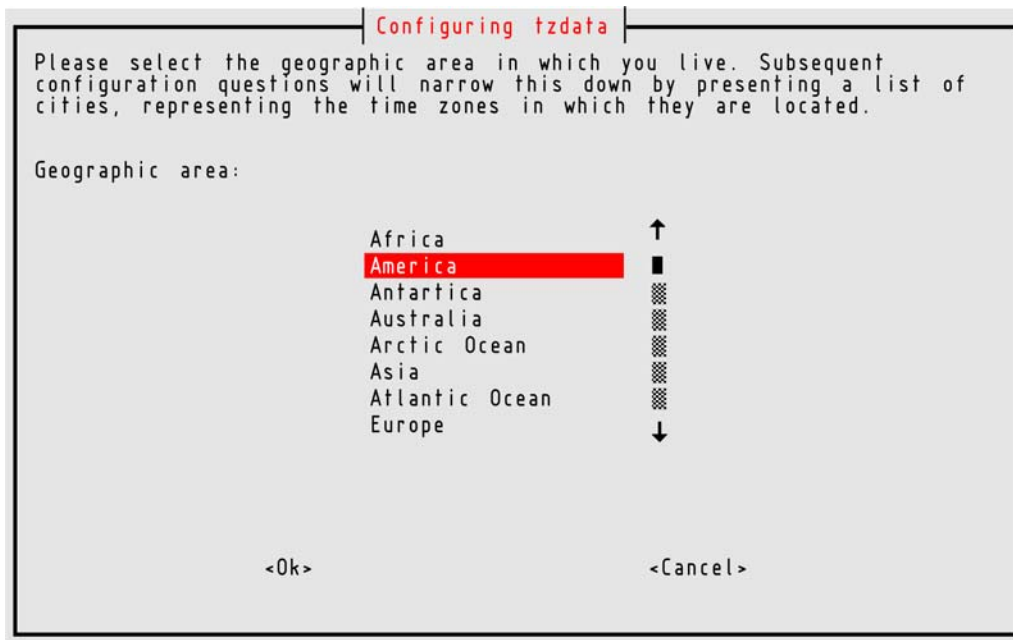
Click on the start program icon in the left corner of the bar.

Click on **Accessories** and then click on LXTerminal.

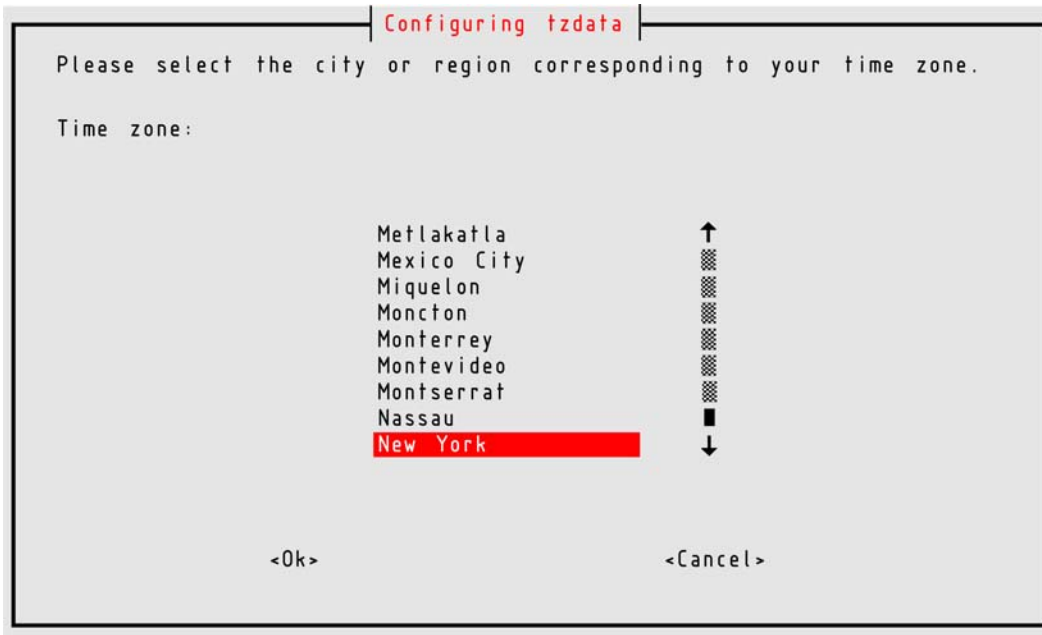
When the terminal window appears, type: **sudo su**

The system cursor should now be: #

Type: **dpkg-reconfigure tzdata** the “configuring tzdata” window will appear.



Select the proper geographical area by scrolling through the menu with the up/down arrows. Select the area by pressing **Enter** when the proper area is highlighted.



Select the nearest time zone by pressing the up/down arrows and highlight the proper time zone area for your location.

Press **Enter** to select.

The window will automatically exit.

If successful, the tzdata configuration window will display the selected time zone:

```
Current default time zone: 'America/New_York'  
Local time is now:      Tue Aug 21 09:33:17 EDT 2018.  
Universal Time is now: Tue Aug 21 13:33:17 UTC 2018.
```

The time and date can now be set.

At the command prompt in the terminal window, type: `settime.sh` [Enter]

The terminal window will clear and a message indicating that the date and time will be written to the battery backed RTC. And the first prompt for the month should be on screen:

```
This script sets the system time and date then writes
the date and time to the battery backed RTC

Enter month [01-12]: █
```

Enter the month ( 01-12 ) *Note that all single digit entries must be preceded by a zero*

Enter the day ( 01 – 31 )

Enter the year ( 2018 )

Enter the hour ( 01 – 24 )

Enter minutes ( 01 – 59 )

After the last entry, the script will end and display that the battery backed clock has been read. The results will be displayed to confirm that the RTC has been properly set.

The terminal window can now be closed.

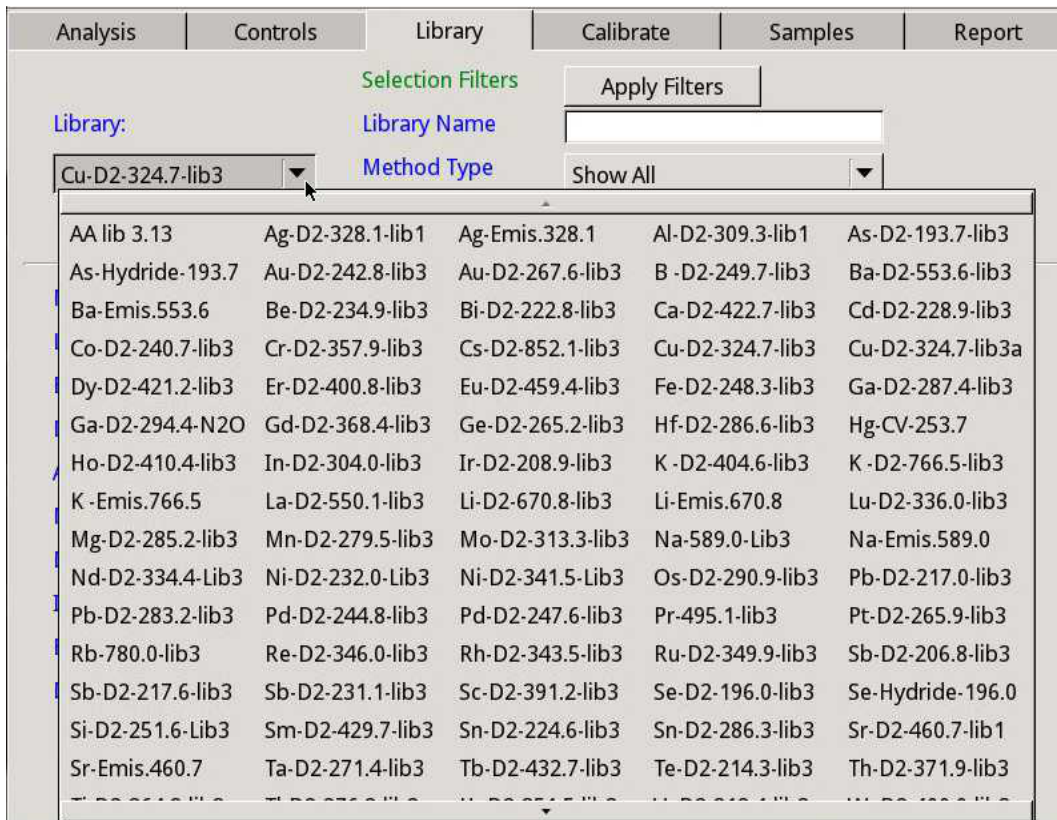
Click on the start program icon and click on Accessories. Click on the M230 icon to restart the M230 program.



## SECTION 2.2: Instrument Operation-Preparing the Instrument

### *Loading the Library:*

Pick the desired lamp position in the analysis screen and select (if necessary). Have the hollow cathode lamp for the element you are analyzing ready. **Do not plug the lamp in yet!** Select the Library tab screen. Press the Library Name button and select the element desired from the drop down list. Be sure to select the correct entry, as there may be more than one entry per element.



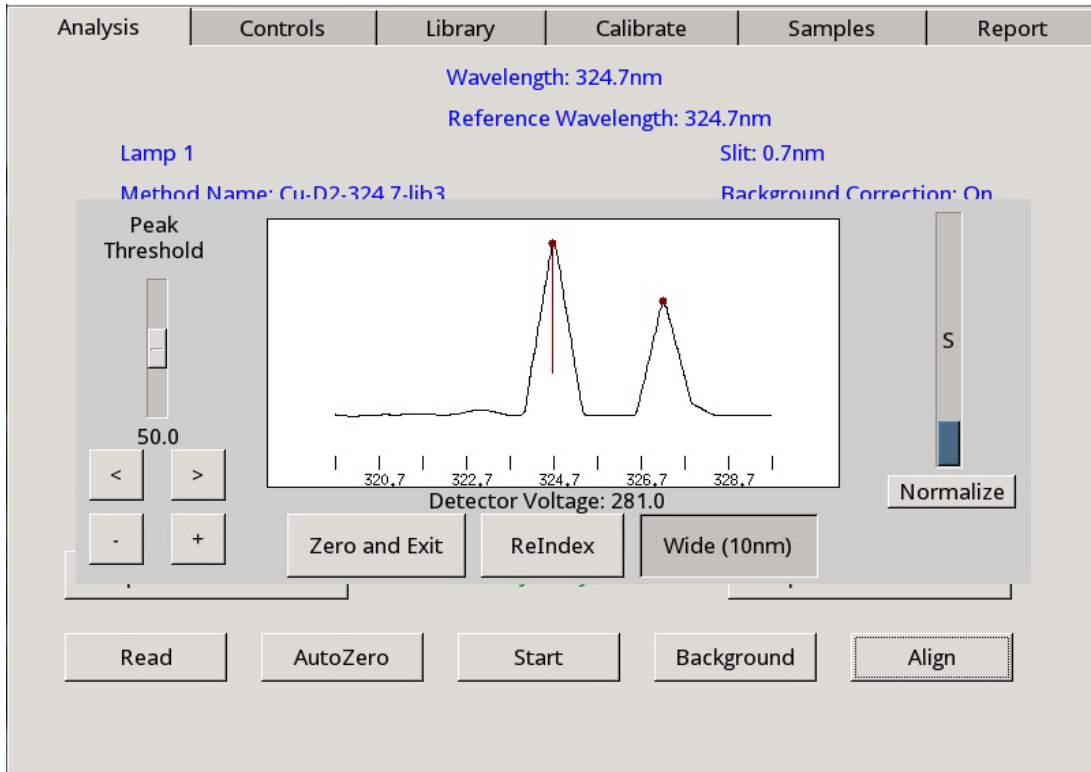
Press the update button to load the library. When the wavelength and slit motors stop, return to the analysis screen. Lift up the lamp turret door and rotate the turret until the top lamp position is the same as the lamp position selected. Insert the lamp fully into position and attach the lamp power cable. Be sure the cable being used has the same number marking as the lamp position.

*Note: If you are performing an emission mode analysis no lamp is needed.*

## SECTION 2.2: Instrument Operation-Preparing the Instrument (cont.)

### *Finding the analytical peak:*

Press the align button. A graph will appear showing a spectrum around the analytical wavelength selected. There may be more than one peak shown. Select the analytical spectral line desired. *Be sure the correct peak is selected, especially when using a 0.2nm slit setting.*



*Align peak graph, Wide (10nm) display.*

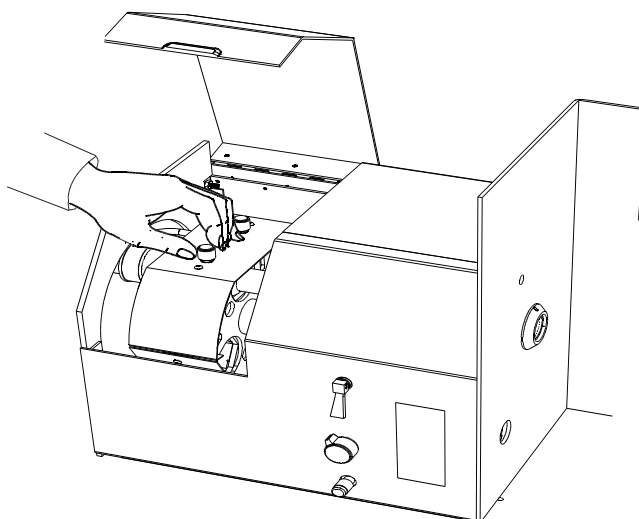
## SECTION 2.2: Instrument Operation-Preparing the Instrument (cont.)

### *Peaking lamp energy:*

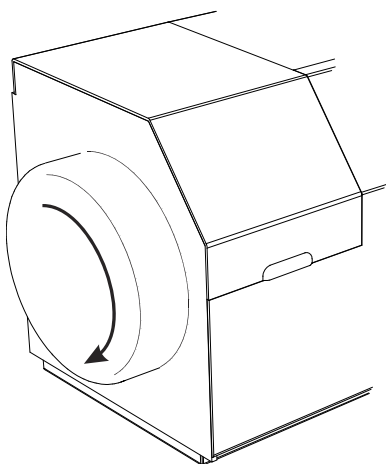
Note the Sample Energy reading in the alignment screen in the bar graph on the right side of the screen. Adjust the horizontal and vertical lamp adjustment knobs to obtain the highest energy reading possible. See the illustration below. Be sure to alternate between the two adjustments several times, as they do interact, until no further improvement can be made. If the energy level reaches the top of the graph press normalize to center it again. When done press the Zero and Exit button.

### *Alternate lamp energy peaking method:*

The lamp can also be adjusted when in the analysis screen by watching the sample energy level while adjusting the lamp knobs for the highest energy possible. Press Autozero when finished. An align should still be performed to be sure you are on the correct analytical spectral line (see previous page).



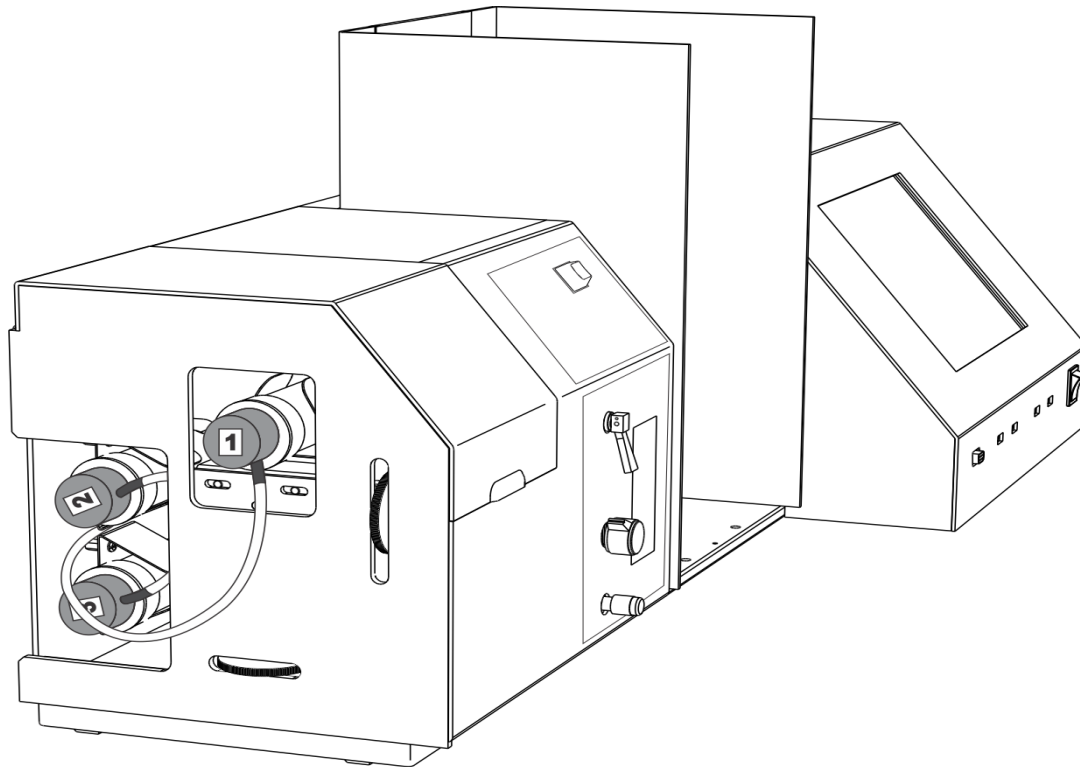
***Lamp Horizontal and vertical position adjustment***



To remove the lamp cover, turn slightly clockwise. And pull cover out of opening.

To reinstall the cover, align the cover with the pins and insert into opening. After the cover is seated, turn slightly counter clockwise.

## 225 Lamp position adjustment:



*Lamp adjustment controls, model 225*

Lamp adjustments on the model 225 are located on the side of the instrument. The lower knob adjusts the lamp up and down or the vertical direction.

The knob located center right adjusts the lamp left to right or horizontally.

The lamp can also be moved in and out of the holder slightly to adjust the focus and increase the usable sample energy. *Note that some element lamps, adjusting the focus will not have an effect on the sample energy.*

The operator should be aware of how tightly the lamps are fitting into the clip mounts. If the mount holding the active sample lamp becomes too loose. It could effect accuracy and make it difficult to hold a steady sample energy voltage.

The clips can always be bent down and inward to tighten them up to hold the lamps properly.

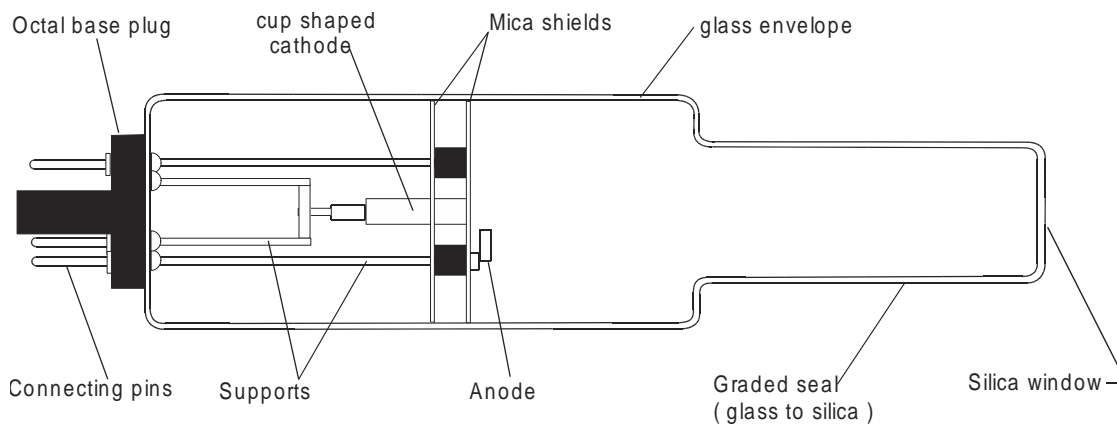
## SECTION 2.2: Instrument Operation-Preparing the Instrument (cont.)

### *Handling and operation of hollow cathode Lamps:*

Buck Scientific hollow cathode lamps are ideal for use with atomic absorption spectrophotometers. Spectral lines of the required element are pure, sharp and of narrow band width.

All Buck Scientific lamps have labels that identify the element and wavelength of the primary line along with operational limits.

The lamps should be kept clean ( no finger prints or chemical smudges on the main silica emission window ).



***Hollow Cathode Lamp***

When installing or removing lamps from a 200 series AA that is on and operating, the operator must be aware of the high voltages associated with the lamps.

Keep fingers away from the connecting pins on the lamps when removing or installing them into the lamp sockets.



***Broken sockets or damaged cables should be repaired to prevent a shock hazard to the operator.***

## SECTION 2.2: Instrument Operation-Preparing the Instrument (cont.)

The burner and nebulizer are factory set and should not require adjustment during initial use. If there has been any maintenance performed, if the instrument should require these adjustments, or you are running a special analysis see **Section 3.1: Flame analysis- optimizing the flame** and **Section 5: Maintenance and Troubleshooting** manual sections.

**FLASHBACK HAZARD: ALWAYS** turn on the air first, and shut it off last. Make sure the drain tube has a loop approximately 8 inches in diameter for proper drainage and to prevent acetylene from flowing into the waste vessel. **NEVER** use glass or something that can shatter as the waste vessel.

*Note: If performing a Nitrous Oxide-acetylene analysis see Section 2.2 for special instructions.*

### **Igniting the Flame-**



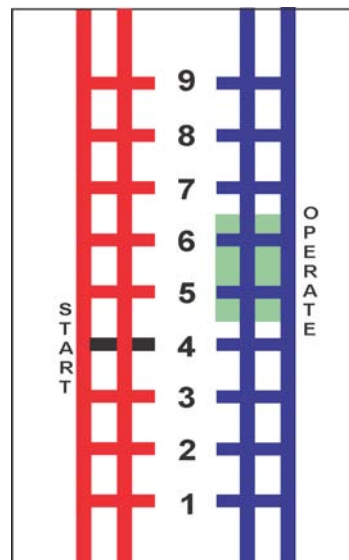
***Make sure your instrument ventilation is on.***



***Make sure that the glass safety shield is installed.***

- 1) Turn the acetylene tank on and set to 12-15psi.
- 2) Turn the air tank on ( or air compressor) and set to 50-90psi.
- 3) Switch the Oxidant selector on the 225/230 front panel to air. The flow indicator (blue scale) should be between 4.5-6.5.
- 4) Turn on the fuel valve on the 225/230 front panel and adjust the flow to the 4 on the red scale.

Continued next page...



***200 series rotometer flow gauge***

- 5) Light the burner by pressing the **ON** button located on the front panel 235 auto gas box controls.

On the model 225/230 press the **Flame Ignite** button.

Alternatively, if the flame ignitor is not working, in an emergency the flame can be lit by a sparker or gas lighter.



*Sparker*



*Light the flame with the glass shield in place.*



*Do not attempt to light the flame and then install the shield.*



*Do not touch the burner head at any time after it's been lit. Even when the flame has been extinguished, the burner head remains hot for a extended period of time.*



*Utility gas lighter*

### ***235 Push button ignition***

Momentarily pressing the **ON** button puts the ignitor into the flow of the burner head and ignites the flame and then will automatically retract.

### ***225/230 Push button ignition***

The operation of the ignitor on the 225/230 is limited to just an ignitor. These models do not include auto gasbox controls and safety interlocks.

Momentarily pressing the **Flame Ignition** button puts the ignitor into the burner head gas flow and then automatically retracts. If the operator is having difficulty lighting the flame, the button can be held down and the ignitor will remain in the gas flow until the button is released. *Note that this will decrease the life of the ignitor faster than momentarily pressing the button.*

### ***Shutdown***

While the flame is lit, turn off the fuel flow making sure the flame shuts down. Aspirate distilled water for a few minutes with the air still on to cool the burner and flush it out. The flame is now shutdown.

### ***Shutdown for the night***

With the flame off and ventilation on, turn off the acetylene at the tank. Turn on the fuel at the instrument, when the flow meter has dropped to 0 the fuel line has been bled. Now turn off the fuel knob and any other gasses at the tanks. *Do not turn off the instrument yet.*

### ***Turning off the instrument***

Select the Controls screen. Press the Shutdown button. Wait until the display changes to a blue color and indicates a blue “no input signal”. Turn off the power switch.

*Note: If you turn off the power switch before the shutdown is complete, your instrument settings will not be saved.*



## SECTION 2.3: Instrument Operation-Running A Nitrous Oxide-Acetylene Flame

- 1) Remove the air/acetylene burner head by removing the 3 hex nuts on the top of the burner assembly just below the burner head. Remove the head and install the 5 cm nitrous oxide head making sure that you re-install the 3 nuts, the o-ring is in place, and the attached interlock plug is inserted. Do not over-tighten the nuts, finger tight plus a 1/4 turn is good enough.
- 2) Align the burner head exactly the same way as you would with the air/acetylene head. Keep in mind that your absorbances will be 1/2 of that which you got for the air acetylene head because the burner slot is 1/2 as long. Generally, the burner height will be 1 turn lower than with Air/Acetylene and the horizontal control always needs adjustment after switching burner heads.
- 3) Make sure that the nitrous oxide is hooked up to the rear of the instrument, that the regulator is set to 50-60 psi and that you are using a ambient air/heated regulator.
- 4) Ignite the flame as usual running air/acetylene. **Never ignite or shutdown the flame in nitrous mode.** After the flame is lit, adjust the fuel flow so that the flame is a rich yellow and is smoky at the top. This might require a number of turns of the fuel knob past the point where the flow meter ball hits the top of the scale.
- 5) In one motion turn the oxidant selector switch to the N2O position, **do not stop in the middle.** At this point the flame should have a red cone at the top of the burner head about 1-2 inches high. Adjust the fuel so that the inner red cone is about 1/2 an inch high.
- 6) Proceed with your analysis.
- 7) To shutdown Turn the oxidant selector switch, **again all in one motion back to the air position,** adjust the fuel flow back to the normal position of approximately 4. Turn off the fuel.

### **Important note: Buffers for Nitrous Oxide**

Spectrographic buffering is essential to minimize the effects of ionization in either a nitrous oxide flame or a rich air-acetylene flame (for doing chromium, tin or barium by air). Analysis without buffering may produce erroneous readings.

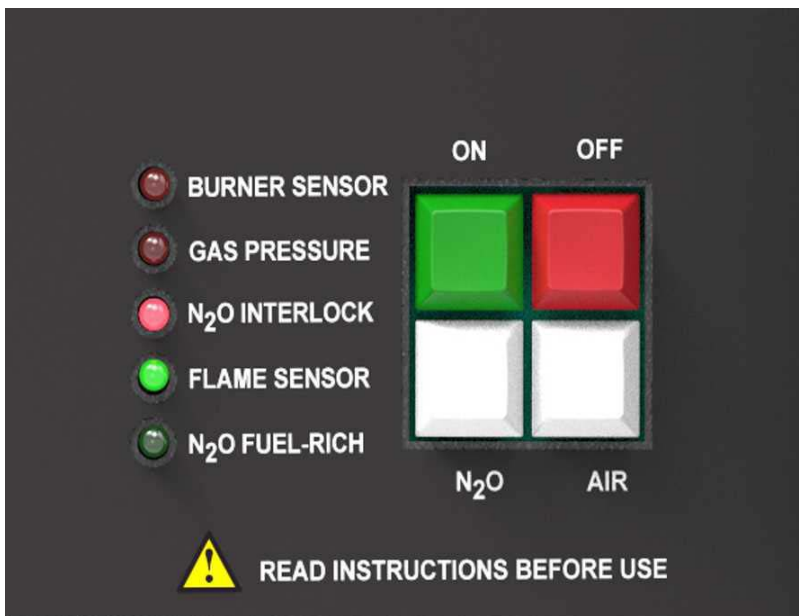
### **For Calcium, Strontium and Barium: Use Lithium buffer & Lanthanum release agent**

Lanthanum is generally used for the alkaline earths to minimize the chemical interferences from phosphate and occasionally sulfate. Dilute all samples, blanks and standards so that they will contain 1000ppm (0.1%) of both the buffering and releasing elements by adding 10ml of each solution to 100ml of prepared final solution.

### **For all General nitrous oxide work: Use Lithium & Potassium buffers**

*Dilute all samples, blanks and standards so that they will contain 1000ppm (0.1%) of the buffering element by adding 10ml of buffer to each 100ml of prepared final solution. Lithium may give better results than Potassium in certain circumstances, depending on the sample matrix and flame conditions.*

## SECTION 2.4: Model 235 Automated Gas Box Controls and Operation



*Front Panel controls and indicators*

### Button and Indicator Descriptions:

- Burner Sensor:** Indicates a fault at the blow-out plug, the burner head interlock is open or the drain bottle is disconnected. The 235 will not operate or will stop operating when this LED is ON.
- Gas Pressure:** Indicates the Acetylene or Air pressure is below acceptable limits. The 235 will not operate or will stop operating if this LED is ON.
- N<sub>2</sub>O Interlock:** Indicates that the Nitrous burner head interlock is not plugged in, or Nitrous pressure is below acceptable limits.
- Flame Sensor:** Indicates that the 235 has detected the burner head flame. And the instrument is ready to operate.
- N<sub>2</sub>O Fuel-rich:** This LED will turn on after the N<sub>2</sub>O button is depressed and indicates that the N<sub>2</sub>O fuel-rich is ON during operation.

*continued next page...*

**ON Button:** Depressing this button will turn on the gasses and initiate the burner head flame auto ignite in the Air Acetylene mode. The 235 will not respond if either the Burner Sensor and/or Gas Pressure red LED indicator LEDs are on. Correct any fault indications before pressing the ON button.

**OFF Button:** Depressing this button while the instrument is operating will shut off all gasses and extinguish the flame.

**N2O:** Pressing this button will richen the Acetylene and turn ON the Nitrous gas. The N2O FUEL-RICH green LED should remain on during Nitrous Oxide operation. The 235 will not switch to Nitrous Oxide operation if the N2O INTERLOCK LED is lit,

**Air:** Pressing this button will turn on the air flow to give the operator indication of the flow rate via the rotometer on the front panel. If an Nitrous Oxide-acetylene flame is being used, the flame will switch to Air-acetylene.

## **235 Safety Features:**

The auto gas box incorporates several safety features which will either stop the instrument from being ignited or stop ignition in the case of a failure.

Flame sensor: Turns off all gasses if the flame has been detected to be off.

Drain sensor: Prevents or stops ignition if the trap is not filled with water.

Blow out plug sensor: Prevents or stops ignition if the plug is not installed.

Burner head sensor: Insures the proper burner head is installed for the gasses being used.

Power failure detection: Shuts the flame off if a power failure is detected.

Keyboard detection: Shuts down the flame should a improper key selection be made.

## Igniting the Air/Acetylene Flame:

The auto gas box has a drain sensor that is in line with the drain tube. Fill the sensor with water by unscrewing the top until water is seen coming out the bottom hose. If this is not filled with water, the flame will not light. Make sure the drain sensor is hanging vertically. Connect the drain line to the spray chamber and make the electrical connection.

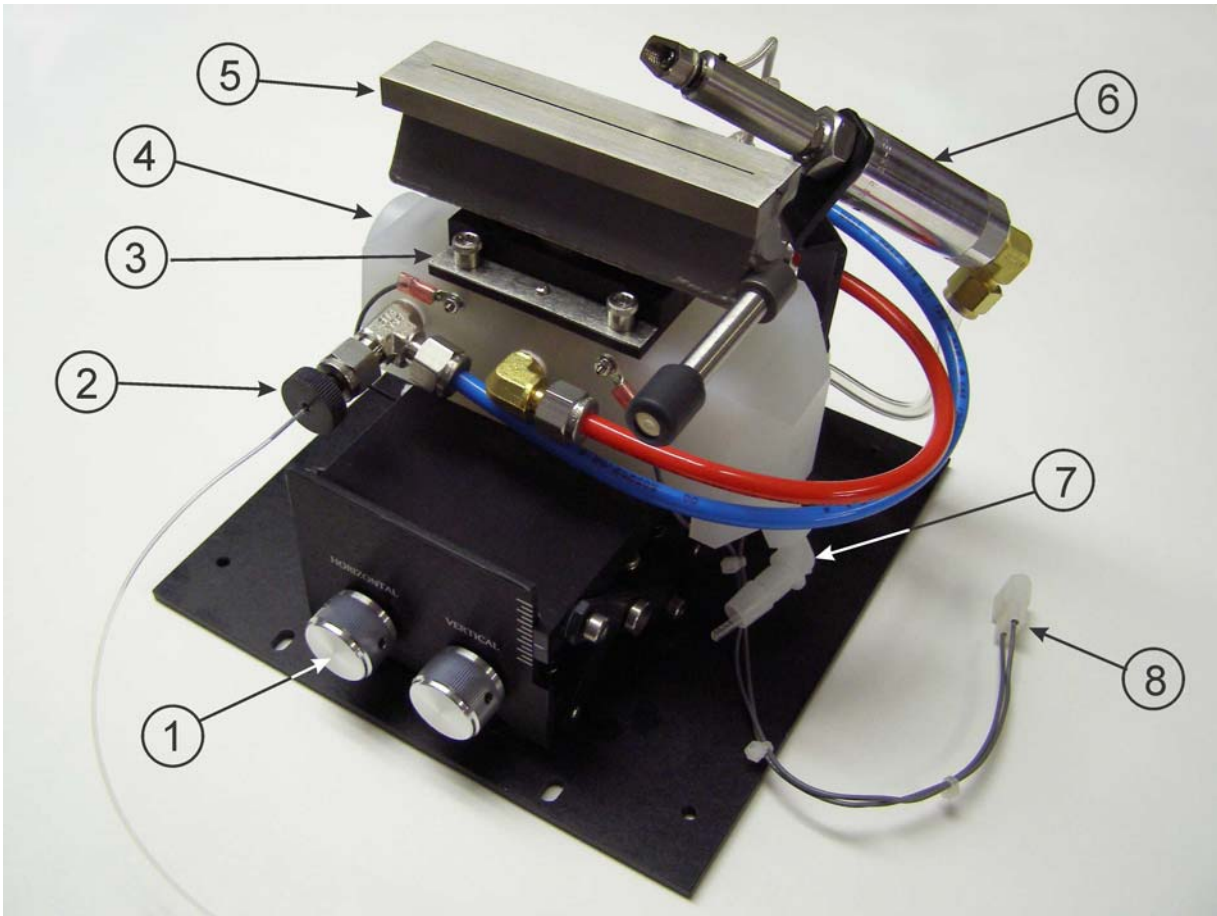
The other end of the drain line should go to a plastic acid resistant waste container.

1. Set the Air inlet pressure to 60 psi and the acetylene tank pressure to 13 psi.
2. Press and hold the AIR button on the front panel and check to verify that there is at least a flow of 5 on the rotometer for both the air and acetylene gases. Adjust the acetylene flow up to 4 if necessary or the flame will not ignite, release the AIR button.
3. The interlock lights should all be off except for the N<sub>2</sub>O interlock LED. If the BURNER SENSOR LED is on, then either the water needs to be added to the drain sensor or the burner head or blow out plug are not properly in place.
4. Press and hold the ON button for 5-8 seconds until the flame ignites, then release the button. If the flame does not ignite, recheck the gas flow and repeat.
5. After ignition, adjust fuel to the required level for the analysis being performed. At this point, the ON, AIR and N<sub>2</sub>O buttons are disabled.
6. To shut the flame off, press the OFF button and the gases flows will stop and extinguish the flame.

## Igniting the Nitrous Oxide Flame:

1. Remove the 3 nuts holding the acetylene burner head in place, remove the acetylene burner head.
2. Make sure the o-ring is in place, then install the nitrous burner. Tighten the 3 nuts and connect the interlock pin. ***Be careful not to overtighten the 3 nuts retaining the burner head.***
3. Press the AIR button and check for proper ignition flow rates.
4. Press and hold the ON button for 5-8 seconds until the flame ignites.
5. Press the N<sub>2</sub>O button and release. The flame will first switch to a bright yellow flame to a bluish, tall nitrous oxide flame. The flame should have a red feather on top of the burner about 1/2 in. high, if not, adjust the fuel flow for this condition. Do not lower the fuel so much that the red disappears and try to avoid raising the fuel so much as to cause the flame to become white. The more fuel that is introduced, the quicker carbon will build up on the burner slot and will cause readings to drift. Some elements may require a higher fuel flow for optimum sensitivity. The carbon can be removed from time to time with a long handled screwdriver while the air/acetylene flame is lit.
6. To shut off the nitrous flame (normal), press the AIR button to switch back to an air based flame, then after 10 seconds press the OFF button.
7. To shut off the nitrous flame (emergency), just press the OFF button and the system will immediately purge all the flammable gases from the system with a puff of compressed air to extinguish the nitrous flame with a gentle "popping" sound. This is not a flashback but a safe "forced shutdown" of the flame.

## X-Y Table/Burner Assy:

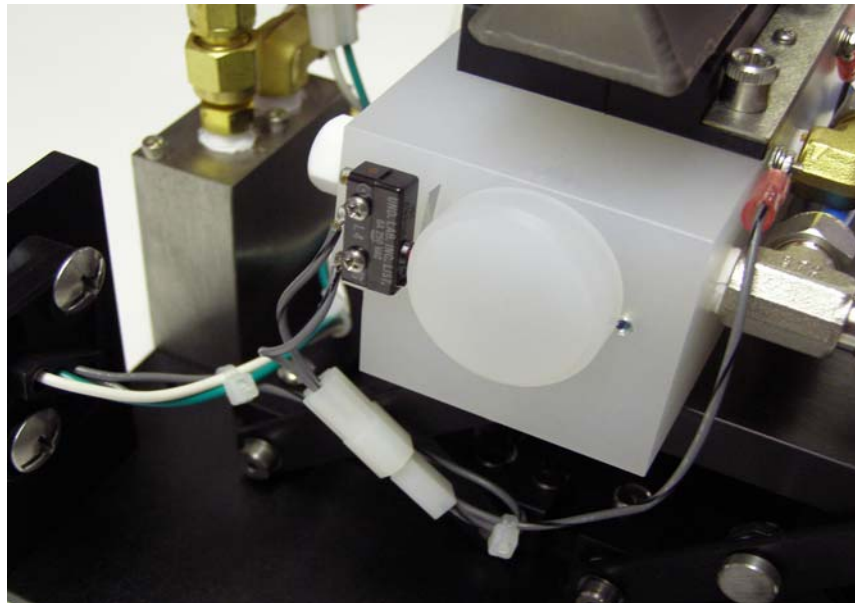


*X-Y Table/Burner Assembly*

### **X-Y Table/Burner main components:**

- |                                |   |
|--------------------------------|---|
| 1. X-Y table position controls | 5. Burner head                          |
| 2. Nebulizer                   | 6. Auto-ignite assembly                 |
| 3. Burner head interlock       | 7. Drain connector                      |
| 4. Blowout plug                | 8. Drain bottle safety switch connector |

*Depending on the model, all of the above components may or may not be incorporated on the supplied X-Y table/burner assembly.*

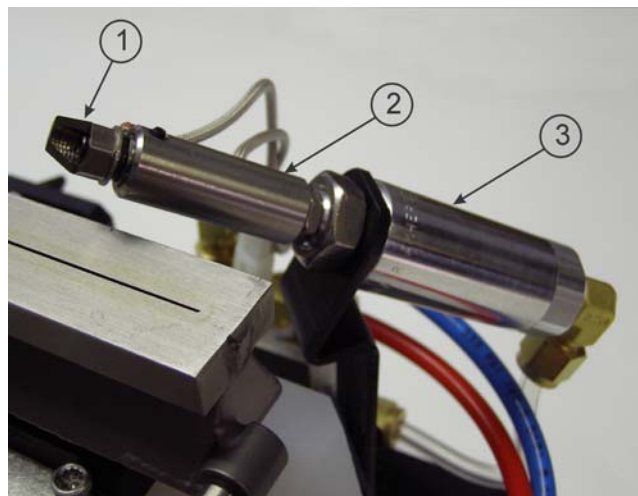


*Blowout Plug Safety Switch*

The blow out plug switch, burner head interlock and drain bottle safety switch are connected in series on the x-y table harness. A failure of any of the switches/interlock will indicate a failure by lighting the BURNER SENSOR LED on the front panel.

### **Replacing the glow plug:**

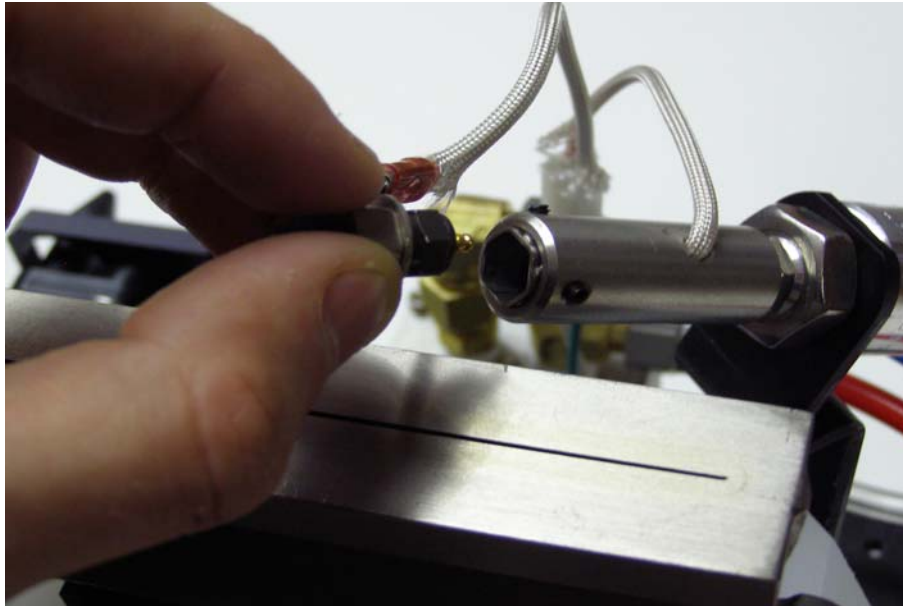
1. Glow plug Assembly
2. Extender/holder
3. Air Actuator



*Auto Igniter Assembly*

To remove the glow plug assembly from the extender/holder, hold the extender/holder tube with your fingers.

Grasp the glow plug assembly. Press in the glow plug assembly and turn counter clockwise. Slowly pull the glow plug assembly from the extender/holder.



A 3/8 inch and 5/16 inch wrench will be required to unfasten the glow plug from the glow plug assembly.

### **To reinstall the glow plug:**

Reassemble the glow plug assembly with the new glow plug.

Place the glow plug back into the extender/holder, press in and turn the glow plug assembly clockwise to lock the glow plug assembly into the extender/holder.

## SECTION 3.1: Flame Analysis- Optimizing the Flame

### *Aligning the burner*

<b>Vertical adjustment</b>	Right knob (burner moves up & down)
<b>Horizontal adjustment</b>	Left knob (burner moves front to back)

With the flame and gasses off place a business card or similar surface on top of the burner so that you can see the lamp image on the card. Rotate the vertical adjust knob so that the bottom edge of the light at the focal point is approximately 4mm from the top of the burner (best position for most analysis). Adjust the horizontal if necessary to get the image over the burner head slot, this is only a rough adjustment for the horizontal. (NOTE: Some elements may require different height settings especially when using nitrous oxide, consult the standard conditions section for these instances). Another way to set the Horizontal position is to lower the burner head until it is clearly not blocking the beam. Perform an autozero. Slowly raise the burner head while watching the absorbance display. When the burner head intersects the beam the number will suddenly go positive and the sample energy will lower. As soon as the reaction is noticed, stop and lower the burner about 2 turns of the dial.

Refer to section 2.2 for more information on lamp alignment.

### *Optimizing the Flame*

Most elements run well with a lean blue flame. As a result, setting the fuel at 4 on the flow-meter and adjusting the burner height with a business card as described in Section 2 is sufficient for most elements. However, for elements requiring richer flames (including those requiring nitrous oxide), or if you are having trouble achieving the sensitivity check, optimizing the flame may improve your results. Starting with the burner head 4mm below the beam, light the flame and let the burner warm up a few minutes while aspirating de-ionized water. Zero the instrument then aspirate your high standard. Slowly increase the fuel (turn the fuel adjust counter clockwise) while watching the absorbance reading until you reach the best absorbance. If increasing the fuel does not improve it, try decreasing instead (If you are running nitrous oxide, be careful not to decrease below the 1/2" cone). Since increasing fuel will change the height of the flame, you should then adjust the vertical burner adjustment in the same manner.

### *Sensitivity check*

You may wish to perform a sensitivity check before calibrating to verify that the burner system is working well and adjusted properly. For your element look up in **Table 1 : Flame Atomic Absorption Concentration Ranges** in Section 7 in this manual for the **Sensitivity check** standard under the "Sensitivity Check" column. Make and run a standard of that concentration. If you are unable to obtain a 0.2 absorbance reading, or better, you may need to go through the burner alignment procedure again, clean the nebulizer and burner head (see Section 5 & 6 Troubleshooting and Maintenance) and/or optimize the flame.



## SECTION 3.2: Flame analysis-Calibration

### *Standards preparation*

Before running a calibration, standards must be prepared. It is best if the standards are prepared in the same matrix as the samples to be measured. The highest standard should not exceed the linear range of the element being analyzed. Up to 9 standards may be used as well as a blank.

### *Entering data into calibration screen (before calibration)*

Standards table: Standard concentrations are entered in the Conc column. *Do not enter any value for the Autozero: this value must remain 0.0.* You may enter a description for each standard in the Name column if desired. No values should be entered into the Abs. Column as it will be measured by the instrument when running the standards.

Number of Replicates: Enter the number of times you want to run each standard. *Note: the Autozero (blank) standard will only run once.*

Calibration Type: Enter first, second or third order curve fit as desired. You must have at least 2 standards to use a second order and at least 3 standards to use a third order calibration.

Concentration Label: Select the units of concentration to be displayed. Any of the units in the pull down can be selected, or type any desired unit in the field.

Analysis	Controls	Library	Calibrate	Samples	Report																																												
			<table><tr><td>Cup</td><td>Name</td><td>Conc</td><td>Abs</td></tr><tr><td>140</td><td>Autozero</td><td>0.0</td><td></td></tr><tr><td>141</td><td>Std2</td><td></td><td></td></tr><tr><td>142</td><td>Std3</td><td></td><td></td></tr><tr><td>143</td><td>Std4</td><td></td><td></td></tr><tr><td>144</td><td>Std5</td><td></td><td></td></tr><tr><td>145</td><td>Std6</td><td></td><td></td></tr><tr><td>146</td><td>Std7</td><td></td><td></td></tr><tr><td>147</td><td>Std8</td><td></td><td></td></tr><tr><td>148</td><td>Std9</td><td></td><td></td></tr><tr><td>149</td><td>Std10</td><td></td><td></td></tr></table>	Cup	Name	Conc	Abs	140	Autozero	0.0		141	Std2			142	Std3			143	Std4			144	Std5			145	Std6			146	Std7			147	Std8			148	Std9			149	Std10				
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			Read	Start																																													
			Calculate	Defaults																																													
			<b>-0.033 Abs</b>																																														

## SECTION 3.2: Flame analysis-Calibration (cont.)

### *Running the calibration*

The calibration can be run by pressing the start key. The instrument will prompt you for each standard and standard repetition. Individual standard calibration may also be performed by highlighting the desired standard and pressing the read key. The use of the read key will only run the selected standard once and place the measured value into the table.

### *Calculating the calibration*

After the standards have been analyzed press the calculate button to have the calibration curve calculated. The graph will show the curve and each standard point. The coefficients are also displayed. The formula is:

$$\text{Concentration} = x(\text{abs} - z_i) + x_2 * ((\text{abs} - z_i)^2) + x_3 * ((\text{abs} - z_i)^3)$$

Where abs = measured absorbance and  $z_i$  = zero intercept.

The correlation coefficient of the calibration curve is also displayed. This is the same as the r-squared value.

To clear and create a new calibration table press the default button to reset all the calibration fields.

*When the calibration has been calculated the instrument is now ready to run samples. Enter the Analysis screen when ready. The large display readout will be in concentration units.*

## SECTION 3.3: Flame analysis-Running samples

### *There are three ways of running samples*

- 1) By aspirating the sample and recording the live concentration or absorbance value displayed. This is not preferred due to the noisy nature of the signal.
- 2) Pressing the read button to perform a time averaged reading to be displayed. The displayed reading will be held on the display until released. Release the reading by pressing the release button. The next sample can now be analyzed. The time used for averaging may be changed by pressing the Library button and setting the Integrate time to the desired setting (0.1-99.0). The units of the Integrate time are in seconds.
- 3) Creating a samples table. If you would like to identify the samples in a printable report use this method. This method uses the same time averaging signal as the read button procedure above. The integration time may be changed in the Library tab. This method is detailed below.

### *Setting up a samples table in the samples screen*

Group Name: This can be any description of the sample series about to be run.

First Sample: The # of the starting sample in the table. This is usually 1.

Last Sample: The # of the final sample.

Sample Replicates: How many times each sample is to be run.

#	Cup	Name
1	1	S1
2	2	S2
3	3	S3
4	4	S4
5	5	S5
6	6	S6
7	7	S7
8	8	S8
9	9	S9
10	10	S10
11	11	S11
12	12	S12
13	13	S13

To change the name of the sample use the fields below the table. The left one specifies the # and the right field can be any desired name. Press Apply when finished.

To clear and create a new samples table press the Defaults button.

## SECTION 3.4: Flame analysis-Emission mode

Atomic Emission measures the flame emission of the element being analyzed. Emission mode analysis will read a blank as 0 and a high standard as 100%. A calibration can be set up to read a sample directly in concentration mode.

- 1) Set up as you would for absorbance except choose an emission file from the library screen and do not change the mode to concentration. Update instrument and return to the Analysis screen and press Cancel.
- 2) Unplug or remove the lamp from the top turret position or move the turret to a position that does not have a lamp. Emission mode does not use a hollow cathode lamp or background correction.
- 3) Turn on the flame and while aspirating your high standard press Align. Select the correct analytical line and press the Zero and Exit button.
- 4) Aspirate your blank and press Autozero. Aspirate your high standard and press 100%. Aspirate the blank again and press Autozero. You may need to repeat this once or twice more until the blank reads 0.0 and the high standard reads 100%.
- 5) You may setup a calibration by following **Section 3.2: Flame analysis-calibration**. Samples may then be run.

Note: Due to the nature of emission mode analysis the readings will drift more frequently than when in absorbance mode. It will be necessary to perform Step 4 above at least every 10 minutes during analysis. If measuring low concentrations this may need to be performed more frequently.

## SECTION 3.5: Cold vapor/hydride analysis mode

To perform Cold vapor/hydride analysis it is necessary to have the Buck Model 1018 accessory installed properly on your instrument. Refer to the Model 1018 Installation and Operation manual for details. This is a batch mode analysis where a signal-time integration is performed and analyzed during a reaction occurring in the attached apparatus.

- 1) Set up as you would an absorbance method except select a cold vapor or hydride method from the Library screen. These methods use a hollow cathode lamp and background correction.
- 2) It may be necessary to change the integration time parameter in the Library screen to suit the analysis. The units of this parameter are in seconds. Press the update instrument button if this value is changed.
- 3) The Hydride method uses an extremely lean air-acetylene flame, while the Cold vapor uses no flame. The instrument calculates samples in units of absorbance-seconds. Other than these exceptions, the calibration and sample runs are performed exactly as flame analysis mode described in **Sections 3.2-3.3** of this manual.

## SECTION 4.1: Menu Descriptions and Advanced Features: Analysis screen

The screenshot shows the 'Analysis' screen of a spectrophotometer. The interface is divided into several sections. At the top, there are tabs for 'Analysis', 'Controls', 'Library', 'Calibrate', 'Samples', and 'Report'. The 'Analysis' tab is active. The screen displays various parameters and controls. Callouts on the left side point to specific elements: 'Active Lamp' points to the 'Lamp 1' label; 'Library parameter descriptions' points to the 'Method Name: Cu-D2-324.7-lib3' and 'Lamp Type: Cu Buck Sci' labels; 'Lamp energy' points to the 'Samp Energy = 2.8144' label; 'Lamp selection buttons' points to the 'Lamp 2: Cr-D2-357.9-lib3' and 'Lamp 3: Fe-D2-248.3-lib3' buttons; and 'Analysis operations (described below)' points to the 'Read', 'AutoZero', 'Start', 'Background', and 'Align' buttons. The central display shows a large '-0.000 Abs' value. Other parameters include 'Wavelength: 324.7nm', 'Reference Wavelength: 324.7nm', 'Slit: 0.7nm', 'Background Correction: On', 'Pulse: Normal', 'Detector Voltage: 281.0', 'Read Integration: 3.0 sec', '09/12/2018 01:55', and 'D2 Energy = 2.8656'. The 'Standby Analysis:' label is also visible.

**Active Lamp**

**Library parameter descriptions**

**Lamp energy**

**Lamp selection buttons**

**Analysis operations (described below)**

**Lamp selector:** Chooses a different lamp position. Rotate the lamp turret to the selected position.

**Read:** Perform read operation. Will hold data on screen until release is pressed.

**AutoZero:** Sets current absorbance value to zero.

**Start:** Begins a sample run based on entries made in the Samples screen.

**Background:** Toggles the D2 background lamp on or off. After changing this setting press Autozero.

**Align:** Enters the Alignment screen and performs a survey scan to find the elemental analytical leak.

## SECTION 4.2: Menu Descriptions and Advanced Features: Controls screen

Analysis	Controls	Library	Calibrate	Samples	Report
Display Mode:	Absorbance				
Display and Report Precision:	3				
Hollow Cathode Stay Warm:	Off				
D2 Stay Warm:	Off				
Recorder Response Time:	1 sec				
Remote Data Rate:	2400			D2 Level	Low
<b>Wavelength Zero Offsets</b>					
0.7nm slit offset (nm):	-3.297			Align Width:	Wide (10nm)
0.2nm slit offset (nm):	-4.0				
2.0nm slit offset (nm):	-2.594				Shutdown
Version 0.7.6-dev					

**Display Mode:** Switch between absorbance and concentration mode. A calibration must be performed before using concentration mode.

**Display and Report Precision:** Changes the number of digits displayed in the Analysis screen readings. Changing the reported precision does not affect the accuracy of the data collected.

**Hollow Cathode Stay Warm:** Currently not being used, to be implemented in the future.

**D2 Stay Warm:** Currently not being used, to be implemented in the future.

**Recorder Response time/Remote Data Rate:** Currently not used, to be implemented in the future.

**D2 Level:** Changes D2 background lamp energy.

**Align Narrow/Wide:** Changes default scan setting for the Align screen.

**Wavelength Zero Offset (0.7/0.2 slit):** Factory settings for wavelength corrections.

*WARNING: DO NOT MODIFY as this will change the factory alignment settings.*

**Shutdown:** Used to save current settings and power off instrument.

## SECTION 4.3: Menu Descriptions and Advanced Features: Library screen

Analysis	Controls	Library	Calibrate	Samples	Report
<b>Selection Filters</b> <input type="button" value="Apply Filters"/>					
Library:		Library Name	<input type="text"/>		
<input type="text" value="Cu-D2-324.7-lib3"/>		Method Type	<input type="text" value="Show All"/>		
		Lamp Type	<input type="text" value="Show All"/>		
Method Type:		<input type="text" value="Absorbance Air/Acetylene"/>			
Lamp Type:		<input type="text" value="Cu Buck Sci"/>	Wavelength:	<input type="text" value="324.7"/>	
Background Correction:		<input type="text" value="On"/>	Background Gain:	<input type="text" value="1"/>	
Detector Voltage:		<input type="text" value="281.0"/>	DC Suppression:	<input type="text" value="On"/>	
Average Current:		<input type="text" value="1.500"/>	Peak Current:	<input type="text" value="6.0"/>	
Minimum Current:		<input type="text" value="0.0"/>	Stay Warm Current:	<input type="text" value="1.5"/>	
Data Period:		<input type="text" value="7.0"/>	Data Interval:	<input type="text" value="0.896 sec"/>	
Integrate Time:		<input type="text" value="3.0"/>	Sample Pulse Width:	<input type="text" value="200.0"/>	
Background Pulse Width:		<input type="text" value="0.0"/>	Pulse Delay Time:	<input type="text" value="200.0"/>	
D2 Level:		<input type="text" value="Low"/>	Slit:	<input type="text" value="0.7nm"/>	
<input type="button" value="Update Instrument"/>		<input type="button" value="Revert Changes"/>	<input type="button" value="Save to Library"/>		

The factory library entries have been optimized for typical analysis for each element and should not need to be changed.

**Method Selection Filters:** These include **Library Name, Lamp type and Method type**. This allows you to narrow the library selections by any combination of these parameters. Press **Apply Filters** to implement filtering. The simplest form of filtering involves entering the element symbol (example: Cu for copper) and **apply filters** to get a list of libraries for just that element for the **Library name** selector.

**Warning: Changing the library settings listed below can damage your HCL lamps and/or cause your instrument not to function properly and give invalid data-Be sure you know what you are doing.**

**Any changes made in the library screen do not take effect until the update instrument button is pressed. An alignment must be performed, as all parameters are reset.**

**Lamp Type:** Description of lamp (optional).

**Method Type:** Selects analysis type- air (or N2O)-acetylene flame, emission or cold vapor/hydride.

**Wavelength:** Direct entry of wavelength setting.



## **SECTION 4.3: Menu Descriptions and Advanced Features: Library screen (continued)**

**Background Gain:** Selects scale setting for alignment screen.

**Detector Voltage:** Changes starting PMT voltage setting.

**DC Suppression:** Set to ON for absorbance, and OFF for emission modes.

**Average Current/Peak current:** HCL lamp current setting. These two parameters are linked. The average current is  $\frac{1}{4}$  the value of the peak current. Changing one will change the other.

**Minimum Current:** HCL current while not collecting data. Should always be set to 0.00.

**Stay Warm Current:** HCL current when lamp not selected. Not currently implemented.

**Data Period:** Data analysis rate. This setting should not be changed.

**Data Interval:** Selects data display refresh rate.

**Integrate Time:** Sets data averaging period or cold vapor/hydride integration time.

**Sample Pulse Width:** Sets lamp on time. This setting should not be changed.

**Background Pulse Width/Pulse Delay Time:** Not currently used.

**Update Instrument:** Press this to implement all changes made on the Library screen

**Revert Changes:** Changes all settings back to the current loaded library default settings.

**Save to Library:** Used to create a new library entry.

## SECTION 4.4: Menu Descriptions and Advanced Features: Calibrate screen

Cup	Name	Conc	Abs
140	Autozero	0.0	
141	Std2		
142	Std3		
143	Std4		
144	Std5		
145	Std6		
146	Std7		
147	Std8		
148	Std9		
149	Std10		

Number of Replicates: 1  
 Fit Order: First  
 Calibration Type: Normal  
 Concentration Label: ppb  
 Coefficient of x: 0.00  
 Coefficient of x2: 0.00  
 Coefficient of x3: 0.00  
 Correlation Coefficient: 0.00  
 Max Concentration: 0.00  
 Zero Intercept: 0.00

Read      Start  
 Calculate      Defaults

**-0.033 Abs**

**The Calibration table:** This is where the standard levels that will be used are entered, so a sample may be calculated directly in concentration. **Name** can be any relevant description. **Conc** is the level of the standard. An **Absorbance** value can be directly entered, but typically the analyst will be measuring this value. The first standard must be the autozero or blank standard

**Number of Replicates:** Specifies how many times each standard is to be analyzed. The absorbance value calculated and indicated in the table will be the average of all the replicates measured.

**Fit Order:** Sets the calibration curve for first, second or third order.

**Calibration Type:** Only normal may be selected.

**Coefficients:** Gives the calibration equation. Where abs = measured absorbance, zi = **zero intercept**.  

$$\text{Concentration} = x(\text{abs} - \text{zi}) + x2*((\text{abs} - \text{zi})^2) + x3*((\text{abs} - \text{zi})^3).$$

**Read:** Reads and replaces the selected standard absorbance (one reading only).

**Start:** Begins a prompted calibration with repetitions specified. The autozero will only run once.

**Calculate:** Updates current calibration coefficients and updates calibration curve graphic.

**Defaults:** Loads the default values erasing the current calibration.

## SECTION 4.5: Menu Descriptions and Advanced Features: Samples screen

#	Cup	Name
1	1	S1
2	2	S2
3	3	S3
4	4	S4
5	5	S5
6	6	S6
7	7	S7
8	8	S8
9	9	S9
10	10	S10
11	11	S11
12	12	S12
13	13	S13

**The Samples Table:** This is where a **Name** or label of a sample can be entered. The **#** and **Cup** values should not be changed. Use the pointer and field at the bottom of the table to change values.

**Group Name:** An optional name for this group of samples may be entered.

**First/ Last Sample:** Specify starting and final sample #.

**Sample Replicates:** Number of replicate runs performed for each sample.

**Apply:** Enters changes made within the pointer and text field above into the samples table.

**Defaults:** Erases all data in the samples table and resets these values to the default settings.

## SECTION 4.6: Menu Descriptions and Advanced Features: Report screen

Ref	Time	Cup	Sample	Rep	Concentration	Abs	Bkg Abs
1	8:49:47 PM		*Auto-Zero*	3	2.510	N/A	2.561 0.00

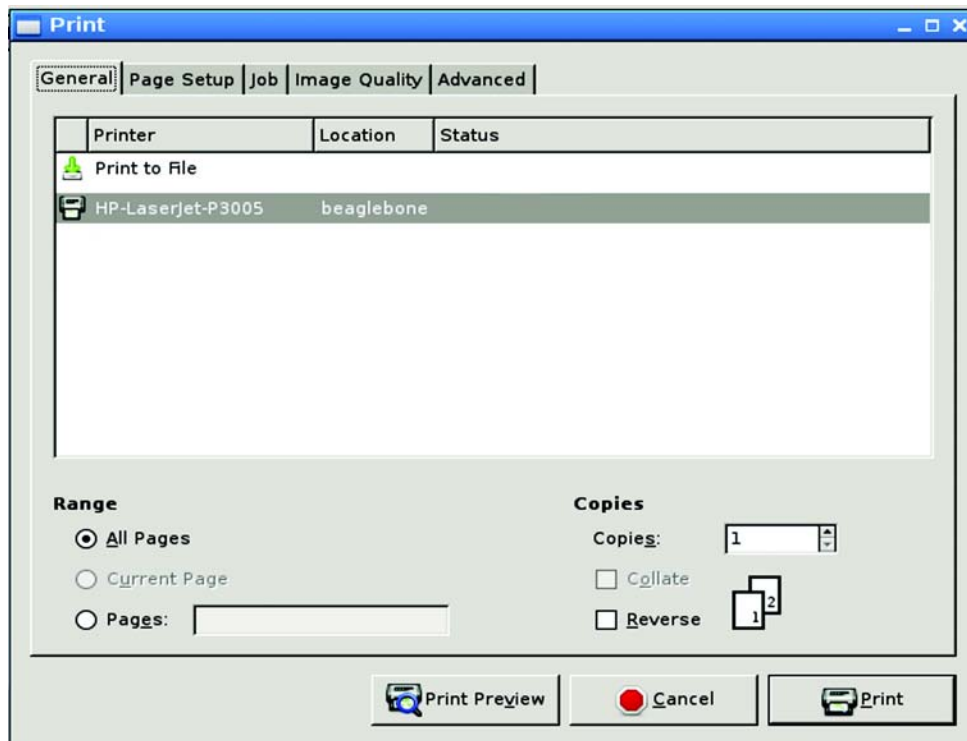
This is a listing of all the data collected in the current analysis.

**Clear:** Clears all collected instrument readings.

**Save:** Allows this table to be saved to a file.

**Print:** Will print out the results on the table. See next section for more details.

## SECTION 4.7: Menu Descriptions and Advanced Features: Printing a report



The Print screen will appear when the Print button is pressed from the Report screen. The installed printer(s) can be print to output your results.

**Printer installation:** There is no printer installation necessary for the model 230 if using a local printer on one of the USB ports. Simply power up and plug the USB cable from the printer into an available USB port on the 230 upon power up. It may take several minutes for the printer to become available in the print screen. A list of compatible printers is listed in the appendix of this manual.

The next section describes finding and installing network printers using the CUPS configuration utility via the installed Linux Chrome browser.

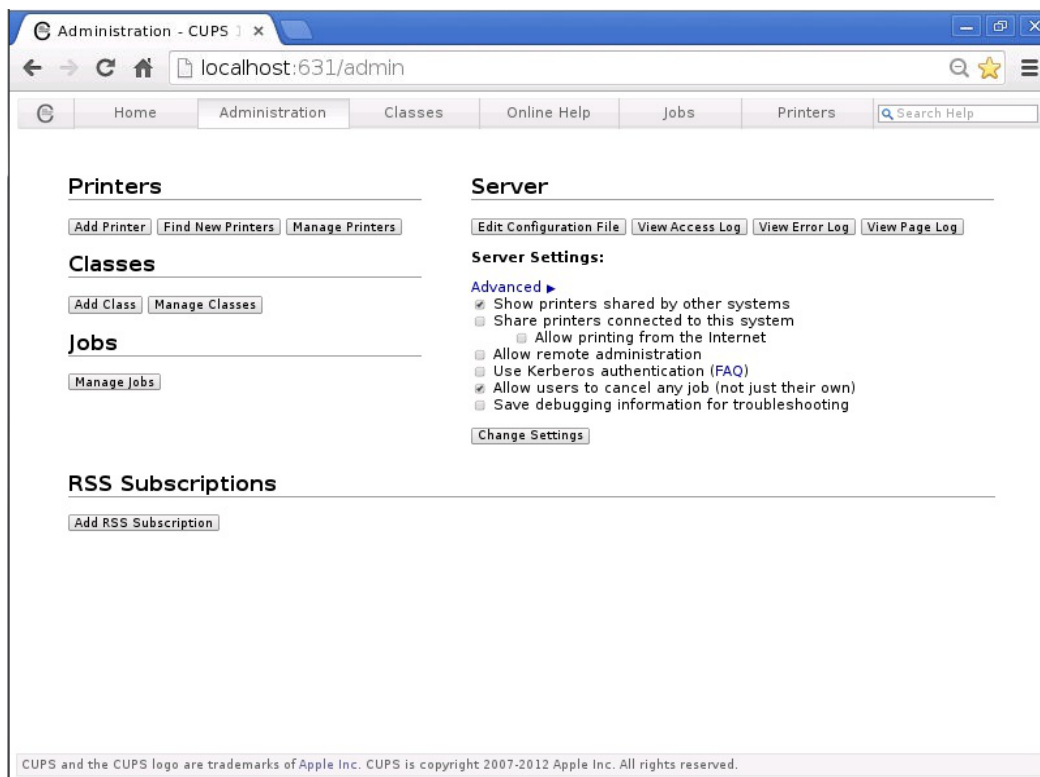
## SECTION 4.8: Installing a network/Local printer with CUPS

### Starting the CUPS printer administration utility :

( The 230 must be connected to a network with internet access. )

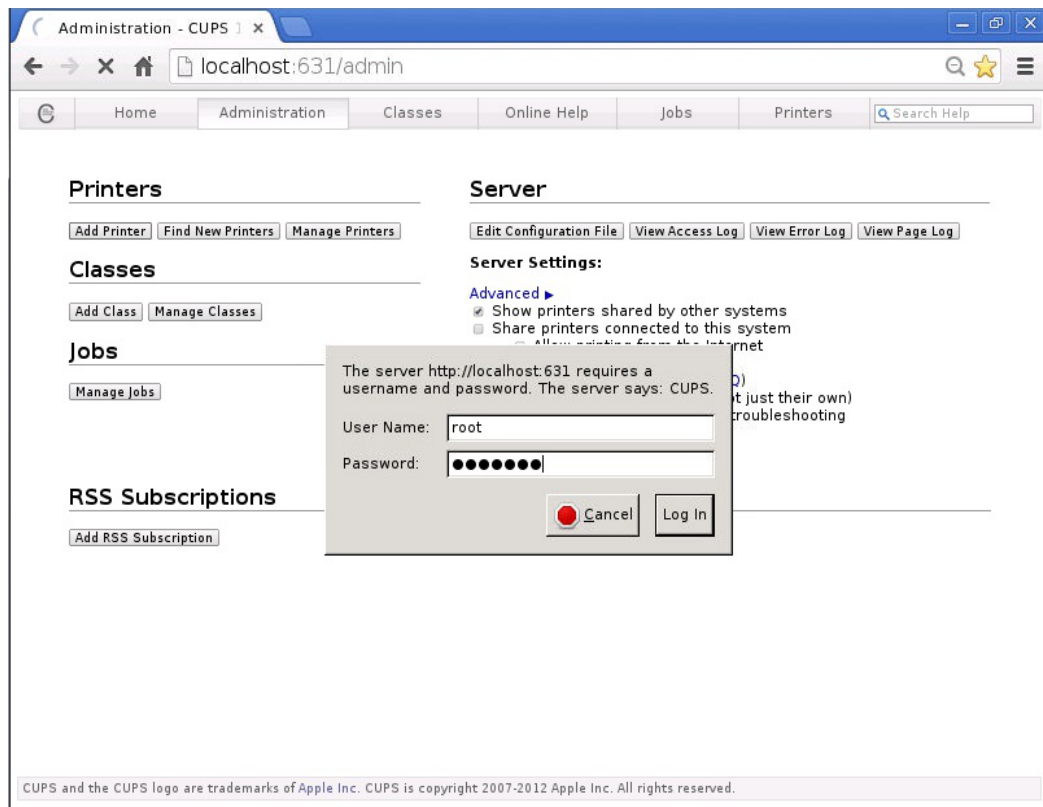
1. Press Alt-F4 to access the Linux operating system.
2. Move the cursor to the bottom of the screen to unhide the task bar.
3. Click on the programs icon on the far left corner. Click on Internet and choose the Chrome browser.
4. Either click on “Administration – CUPS X.X.X” in the bookmarks bar or enter **localhost:631/admin** into the address bar.

The CUPS printer interface will appear in the browser:



## Adding a new printer:

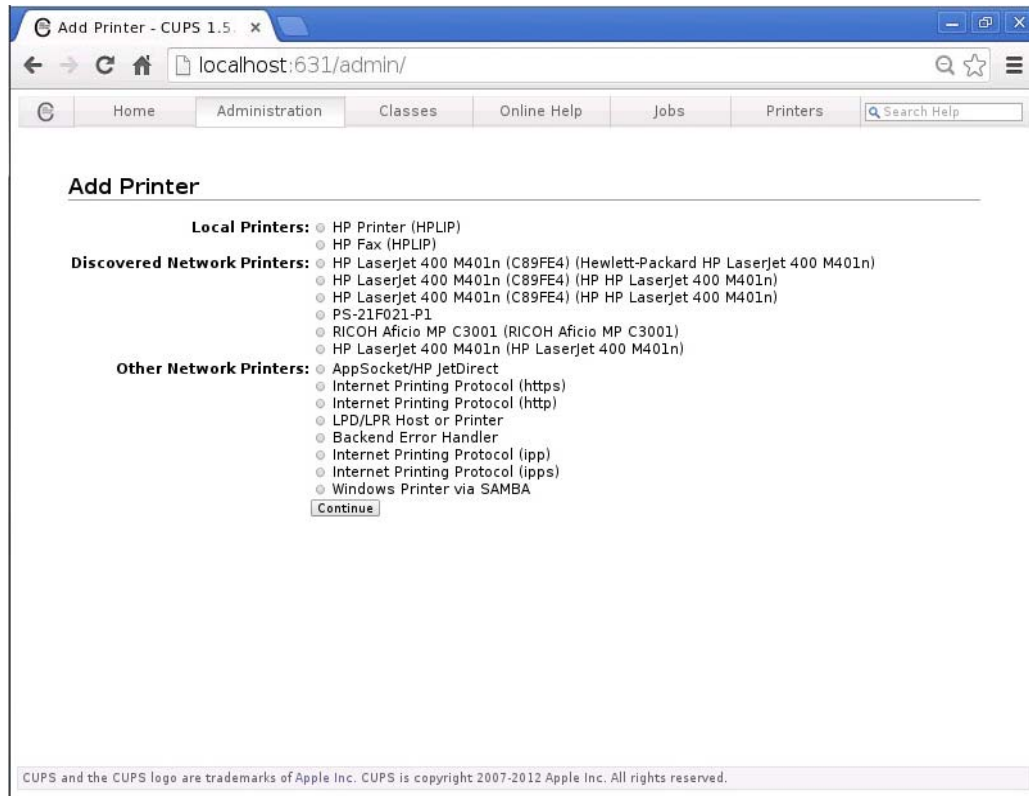
1. Click on the Add Printer button.
2. CUPS will then ask for a User Name and Password to continue. Enter **root** for the user name and **bucksci** for the password.
3. Press the **Log in** button.



## Printer Selection:

CUPS will display a selection of printers available on the network.

Click on the button next to the name of the printer you wish to select for use.

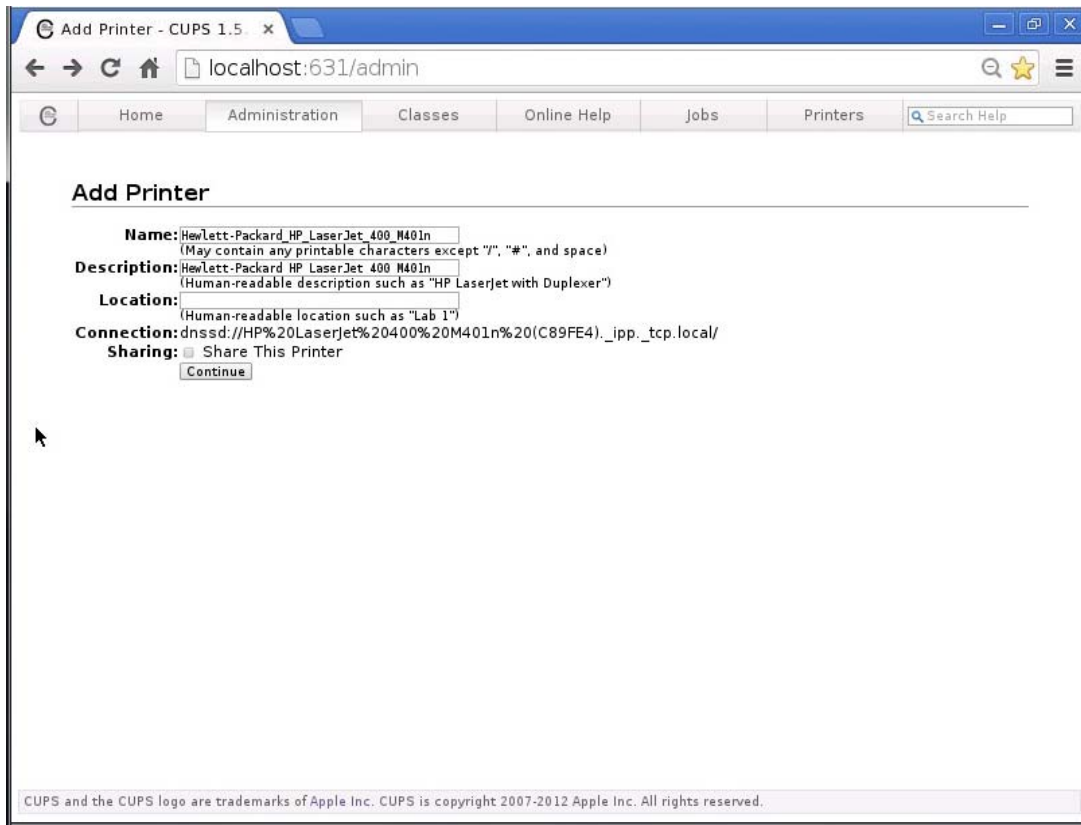


Click on the **Continue** button to progress to the next screen.



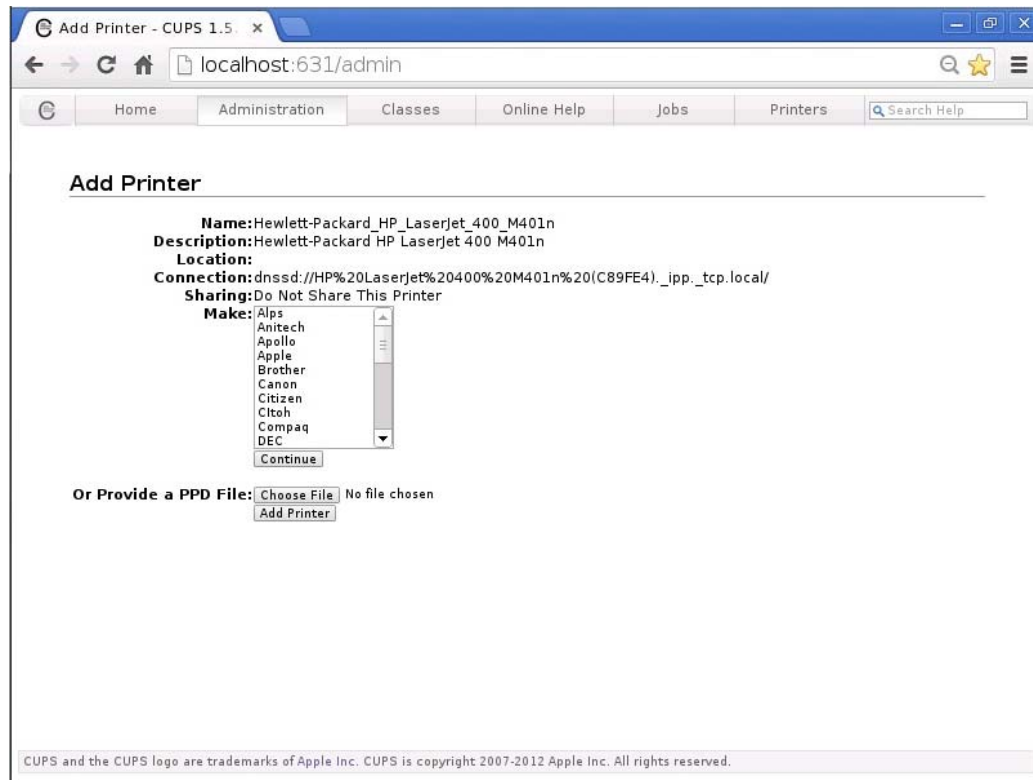
The CUPS utility will then give you a opportunity to change, the name of the printer as it will be displayed for use, the description of the printer. The physical location of the printer and the connection parameters.

If you are unsure what to enter in any of the fields, just leave them as default.



Press **Continue** to progress to the final screen.

The final page of the add printer utility allows the user to select the make of the printer. This is just for reference and does not effect the printer selected in the prior screens.



After selecting the appropriate make of the printer, press **Add Printer** to add the printer to available printers.

## Supplied Printer:

The printer supplied with the 200 series AA systems is the HP 1112 Deskjet.

To load/reload the drivers, make sure the printer is plugged into one of the USB ports and turned on.

Select HP Deskjet 1110 series from the printer selection menu.

Select printer driver **HP Deskjet 1000 j110 series, hpcups 3.12.6** in the driver selection menu.

A test page can be printed by clicking on the Administration tab, and clicking on the manage printers drop down menu.

## SECTION 5: Troubleshooting: Tips and techniques

About 95% of problems are related to the burner system or the lamps, the instrument itself rarely fails.

PROBLEM: LOW ABSORBANCE TYPICAL CAUSES:

- 1) ***Wavelength is not tuned in correctly or is peaked on the wrong spectral line.*** Some elements have many spectral lines in the same region, lines other than the primary line may give you much less absorbance than the primary line. This is common with nickel. Any element that calls for a 0.2nm slit will usually have more than one spectral line in the region. Check in the align screen using the align-wide range if necessary.
- 2) ***Nebulizer either blocked, not tuned correctly or needs replacement due to extended use.*** Check for blockage in the sample capillary (this usually occurs where the plastic capillary meets the nebulizer). The uptake rate for the nebulizer is typically between 8 - 12 ml/min. With a burner head that is cold turn on the air (no fuel) and aspirate water. On a well peaked nebulizer you should see a good mist coming from the burner head slot. As a nebulizer degrades you may notice that the flow rate required for peak sensitivity increases.
- 3) ***Burner system out of alignment.*** For maximum sensitivity the path of the burner slot must be directly underneath the path of the light beam. Refer to the alignment section 3.1 of the manual and proceed thru it step by step.
- 4) ***Fuel / air ratio not correct.*** Most elements work well with a lean blue flame and the ratio does not matter, however some elements may give better sensitivity with more or less fuel. Any element that specifies a rich yellow flame condition needs higher fuel settings to achieve the sensitivity stated in the standard conditions section of the manual. Refer to this section for suggested flame conditions. If you have problems meeting the sensitivity spec, experiment with flame condition for best results.
- 5) ***Burner height not correct.*** Certain elements may also work better if the burner head is lowered. If you increase fuel flow chances are you will need to lower the burner head as well for peak sensitivity.
- 6) ***Acetylene tank low.*** As the acetylene pressure drops you may encounter a decrease in absorbance and an increase in background due to acetone.
- 7) ***Impact bead not adjusted correctly.*** This should not normally need adjustment unless the nebulizer has been replaced or the bead has broken. The impact bead is located at the rear of the spray chamber directly across from the nebulizer. To adjust the bead peak up on any lamp and appropriate wavelength, make sure the background corrector is off then autozero the instrument. With a cold burner head turn the air on at the front of the instrument and aspirate water (DO NOT TURN ON THE FUEL AND LIGHT THE FLAME). You should see a mist coming from the burner head. If not adjust the nebulizer for best absorbance on the main display then using a 1/2" wrench adjust the impact bead for best absorbance. (NOTE: DO NOT ADJUST THE BEAD TO FAR CLOCKWISE OR IT MAY RUN INTO THE NEBULIZER AND BREAK). If you are unsure as to the proximity of the bead to the nebulizer you can remove the spray chamber and remove the blow-out plug on the left side. The bead should be a couple of millimeters from the end of the nebulizer.

## SECTION 5: Troubleshooting: Tips and techniques (continued)

### PROBLEM: DRIFT OR FLUCTUATION IN READINGS: POSSIBLE CAUSES:

- 1) **Lamp.** To determine if it is the lamp turn off the flame and all gasses. Zero the absorbance and watch the display. After warm up, drift should be less than 0.001 per minute and noise should be less than +/- 0.002. Most lamps perform much better than this. If this is stable the problem is probably with the burner system. If a lamp drifts or is noisy, selecting a different operating current may help. Try checking other lamps for the same problem, if all lamps exhibit drift or noise the instrument may be suspect.
- 2) **Burner system.** If drift or noise only occurs during your run then the burner system is in doubt. Check that the drain is working properly. There should be a steady drip or flow. If there is any water buildup in the drain block you will most certainly get a decrease in absorbance. A gurgling sound from the burner is a good indication of this. Make sure the end of the drain tube is not submerged in the waste water. Try readjusting the nebulizer. A new nebulizer may be needed. Make sure there are no leaks in the burner, check the o-rings.
- 3) **Thermal drift.** If the lab is subject to temperature changes the optical bench of the instrument may shift causing a slight change in energy. To determine if this is the problem peak up the wavelength using the align screen Autozero the instrument. If after a period of time the absorbance drifts go back and repeak the wavelength.
- 4) **Unstable supply gas pressure.** Although the instrument has internal regulation, supply pressure change can cause fluctuation of absorbance for any element that is flame sensitive, particularly iron. Air supply: Many failures of the pneumatics or excessive noise in results can be attributed to contaminated air or acetylene. An air filter is a must when using an air compressor for your supply to filter out oil, water & particulates. It should be cleaned on a regular basis. The inside of the plastic bowl should be cleaned with water and soap and the filter element with ethyl alcohol or similar solvent. Refer to the manufacturers instructions for complete information.

### PROBLEM: YELLOW / ORANGE FLAME: POSSIBLE CAUSES:

- 1) **Acetylene:** If you notice your flame becoming orange in color and it is not due to your samples there is acetone coming from the tank, you should shut down when this is noticed. A new tank should sit for at least several hours undisturbed before use to let the acetone settle. Eventually liquid acetone will appear in the flow tube of the acetylene. ***For this reason do not let tank pressure drop below 75psi. As your tank pressure drops more acetone will be introduced resulting in decreased absorbance signal and increased background levels.***

## **SECTION 5: Troubleshooting: Tips and techniques (continued)**

### **MISCELLANEOUS:**

- 1) A 0.500 absorbance screen is supplied with the instrument. It should result in .450 to .550 absorbance when inserted into the light path. This indicates the electronics are working properly.
- 2) Your standards, samples and blank should be prepared in the same matrix as your samples so as to avoid erroneous results.

## **SECTION 6: Maintenance**

The model 230 requires very little maintenance:

- 1) Once a year the o-rings should be checked in the burner system. Remove the 3 cap nut screws holding on the burner head then remove. Check the integrity of the o-ring underneath and replace if necessary. Coating the o-ring with a thin layer of Teflon grease is a good idea.
- 2) Remove the red and blue tubing from the fuel elbow and nebulizer respectively. Disconnect the drain hose. Raise the burner to the full vertical upward position. Remove the screw on the front of the drain block underneath the fuel elbow and pull the drain block out. Remove the blow out plug on the left side. Check and lubricate that o-ring.
- 3) If you see an irregular shaped flame use the cleaning tool provided to clean the burner slot.
- 4) The entire burner assembly can be put in an ultrasonic tank for a thorough cleaning. Remove the burner head, nebulizer and fuel elbow before doing this.
- 5) Keep the lenses on either side of the burner compartment clean for maximum energy. Wipe them with clean lens paper and iso-propyl alcohol, or other solvent.
- 6) An Instrument Qualification (PQ) validation can be performed by our service department if your lab protocol requires it.

### **SECTION 6.1: Instrument Service**

There are no user servicable parts in the model 230.

Only authorised personel should attempt repair of the model 230.

Repairs should be sent to Buck Scientific, please call our technical personel before sending any equipment back for repair.

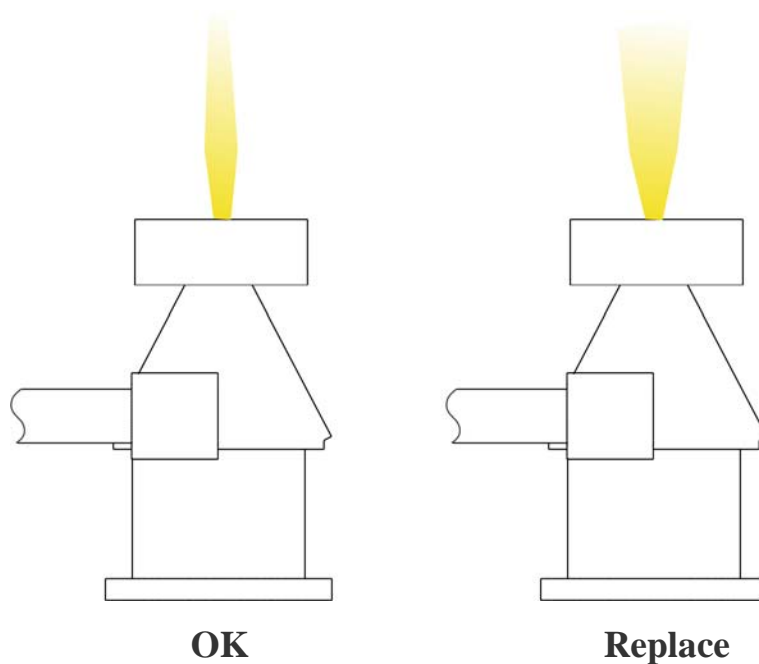
## SECTION 6.2: Burner head Service

### Checking slot widths on burner heads:

The acetylene head will give little indication that the slot is becoming too wide for continued use. Periodic checking of the slot with the supplied gauge/cleaner will generally be the only way to tell if the burner head needs to be replaced.

If the acetylene burner head “pops” when turning off the fuel, this is also a good indication that the slot has become too wide and the burner head needs to be replaced.

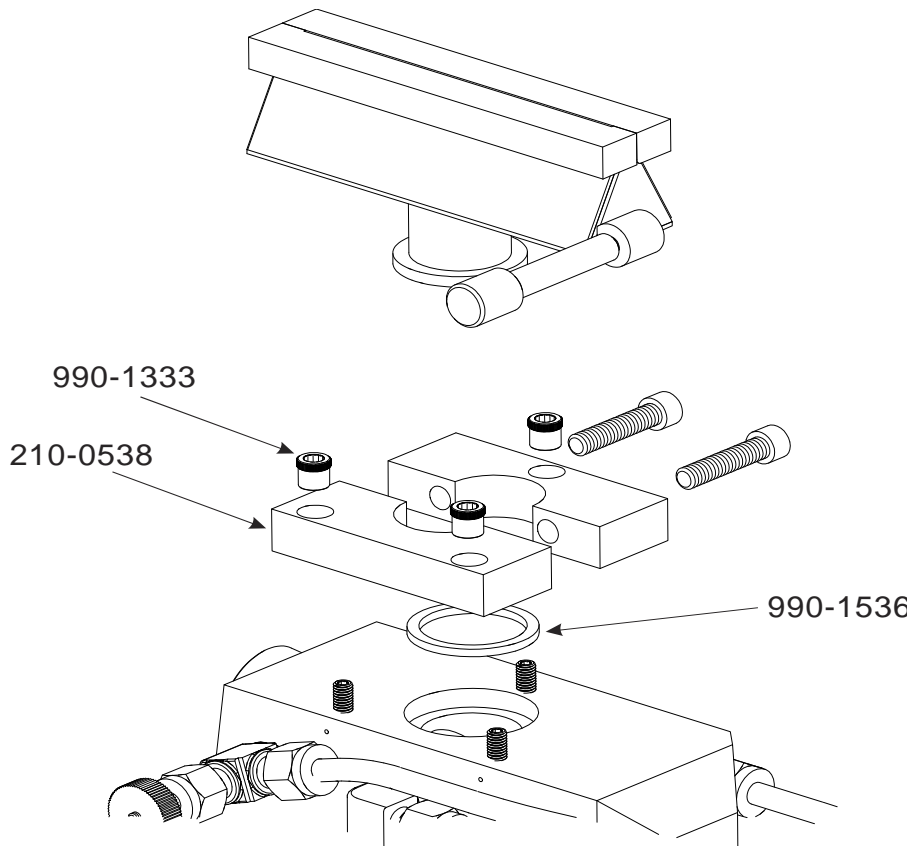
The nitrous burner head will show indication of the slot widening by the flame. The flame will flare out from the slot. If the nitrous burner head exhibits this behavior, **the head should be immediately replaced.**



*Nitrous Burner Head slot wear indication*

**Instructions for replacing the acetylene or nitrous burner head:**

1. Always allow the burner head to cool down before replacing if in operation.
2. Loosen and remove the (3) #10 cap head nuts with the supplied 3/16" hex nut driver.
3. Lift the head and clamp assembly from the burner mixing chamber.
4. Loosen the (2) cap head screws at the back of the burner head clamp so that the head and clamp can be separated.
5. Remove the old o-ring. Ensure that the o-ring seat is clean and free from debris.
6. Place the clamp onto the new burner head and tighten the (2) cap head screws.
7. Place the new o-ring into the mixing chamber.
8. Set the burner head and clamp onto the mixing chamber and replace the (3) #10 cap head nuts.
9. Ensure that the burner head is straight on the mixing chamber, and tighten the (3) cap head nuts.



## SECTION 7: Standard Conditions

### Quick Overview

**Table 1** serves as a quick reference guide to the sensitivity and performance using flame techniques. The detection limits are determined as the lowest concentration given an absorbance detectable above the noise range. These values were determined empirically under Buck Scientific standard test conditions (see Appendix A).

Sensitivity is a measure of the instrument response to the analyte, and by convention, shows the concentration of each element required to absorb 1% of the incident light energy. This corresponds to an absorbance value of 0.0044. Elements with greater sensitivity will have the lowest concentration values in that category. The values for "sens. check" in table 1 are the amounts in mg/l required to give an absorbance reading of 0.200 abs.

The "linear range" is the amount of analyte in mg/l which will produce an absorbance of approximately 0.300 and safely keep the analysis in the linear part of the calibration curve. This area of the curve requires only one standard to be run but an additional standard run as a check is good practice. Above this area a multi-point calibration must be used.

**Table 2** lists alternate wavelengths you can use in order to increase the linear range of your analysis or to reduce interferences from other elements. RS stands for "relative sensitivity". This describes how sensitive this wavelength is compared to the primary wl which will always have a relative sensitivity of 1.0. For example, if a secondary line has an RS of 2 it will give you an absorbance 1/2 of the primary wavelength.

**TABLE 1: Flame Atomic Absorption Concentration Ranges**

<b>Metal</b>	<b>Wl (Nm)</b>	<b>Slit (Nm)</b>	<b>Detec Limit (mg/L)</b>	<b>Sens Check (mg/L)</b>	<b>Linear Range (mg/L)</b>	<b>Flame Type Color</b>
Aluminum (Al)	309.3	0.7	2.00	25	50.00	N-A, rich/red
Antimony (Sb)	217.6	0.2	0.30	12.5	20.00	A-A, lean/blue
Arsenic (As)	193.7	0.7	0.25	22.5	25.00	A-A, lean/blue
Barium (Ba)	553.6	0.7	0.50	10	25.00	N-A, rich/red
Beryllium (Be)	234.9	0.7	0.04	0.75	4.00	N-A, rich/red
Bismuth (Bi)	222.8	0.7	0.10	10	25.00	A-A, lean/blue
Boron (B)	249.7	0.7	---	300	450	N-A, rich/red-wh
Cadmium (Cd)	228.9	0.7	0.01	0.75	2.00	A-A, lean/blue
Calcium (Ca)	422.7	0.7	0.05	2	5.00	N-A, rich/red
Cesium (Cs)	852.1	0.2	---	5	7.50	A-A, lean/blue
Chromium (Cr)	357.9	0.7	0.04	2	5.00	A-A, rich/yellow
Cobalt (Co)	240.7	0.2	0.05	3.5	5.00	A-A, lean/blue
Copper (Cu)	324.8	0.7	0.005	2	5.00	A-A, lean/blue
Dysprosium (Dy)	421.2	0.2	---	22.5	33.75	N-A, rich/red
Erbium (Er)	400.8	0.2	---	15	22.50	N-A, rich/red
Europium (Eu)	459.4	0.2	---	15	22.50	N-A, rich/red
Gadolinium (Gd)	368.4	0.2	---	425	637.5	N-A, rich/red



**TABLE 1: Continued**

<b>Metal</b>	<b>Wl (Nm)</b>	<b>Slit (Nm)</b>	<b>Detec Limit (mg/L)</b>	<b>Sens Check (mg/L)</b>	<b>Linear Range (mg/L)</b>	<b>Flame Type Color</b>
Gallium (Ga)	287.4	0.7	---	30	45.00	A-A, lean/blue
Germanium (Ge)	265.1	0.2	---	50	75.00	N-A, rich/red
Gold (Au)	242.8	0.7	0.20	7.5	10.00	A-A, lean/blue
Hafnium (Hf)	286.6	0.2	---	225	337.5	N-A, rich/red
Holmium (Ho)	410.4	0.2	---	20.0	30.00	N-A, rich/red
Indium (In)	303.9	0.7	---	17.5	26.25	A-A, lean/blue
Iridium (Ir)	264.0	0.2	---	250	375	A-A, rich/yellow
Iron (Fe)	248.3	0.2	0.05	2.5	5.00	A-A, lean/blue
Lanthanum (La)	550.1	0.2	---	1250	1875	N-A, rich/red
Lead (Pb)	283.3	0.7	0.08	10	20.00	A-A, lean/blue
Lithium (Li)	670.8	0.7	---	1	1.50	A-A, lean/blue
Lutetium (Lu)	336.0	0.2	---	125	187.5	N-A, rich/red
Magnesium (Mg)	285.2	0.7	0.005	0.015	1.50	A-A, lean/blue
Manganese (Mn)	279.5	0.7	0.03	1.25	2.50	A-A, lean/blue
Mercury (Hg)	253.7	0.7	~ 5.0			A-A, lean/blue
Molybdenum (Mo)	313.3	0.7	0.80	15	20.00	N-A, rich/red
Neodymium (Nd)	492.4	0.2	---	175	262.5	N-A, rich/red
Nickel (Ni)	232.0	0.2	0.05	3.5	4.00	A-A, lean/blue
Niobium (Nb)	334.4	0.2	---	350	525	N-A, rich/red
Osmium (Os)	290.9	0.2	---	22.5	33.75	N-A, rich/red
Palladium (Pd)	244.8	0.2	0.15	5	10.00	A-A, lean/blue
Phosphorus (P)	213.6	0.2	---	7000	10500	N-A, rich/red
Platinum (Pt)	265.9	0.2	0.80	50	20.00	A-A, lean/blue
Potassium (K)	766.5	0.7	0.01	1	3.00	A-A, lean/blue
Praseodymium (Pr)	495.1	0.2	---	1000	1500	N-A, rich/red
Rhenium (Re)	346.0	0.2	---	325	487.5	N-A, rich/red
Rhodium (Rh)	343.5	0.2	---	4.5	6.75	A-A, lean/blue
Rubidium (Rb)	780.0	0.7	---	25	37.5	A-A, lean/blue
Ruthenium (Ru)	349.9	0.2	---	15	22.5	A-A, lean/blue
Samarium (Sm)	429.7	0.2	---	150	225	N-A, rich/red
Scandium (Sc)	391.2	0.2	---	7.5	11.25	N-A, rich/red
Selenium (Se)	196.0	0.2	0.50	15	25.00	Ar-H
Silicon (Si)	251.6	0.2	1.00	50	50.00	N-A, rich/red
Silver (Ag)	328.1	0.7	0.02	1.25	3.00	A-A, lean/blue
Sodium (Na)	589.0	0.2	0.005	0.25	2.00	A-A, lean/blue
Strontium (Sr)	460.7	0.2	---	2.5	3.75	N-A, rich/red
Tantalum (Ta)	271.5	0.2	---	275	412.5	N-A, rich/red
Technetium (Tc)	261.4	0.2	---	50	75	A-A, rich yellow
Tellurium (Te)	214.3	0.7	---	10	15	A-A, lean/blue
Terbium (Tb)	432.6	0.2	---	150	225	N-A, rich/red
Thallium (Tl)	276.8	0.7	0.40	15	25.00	A-A, lean/blue
Thulium (Tm)	371.8	0.2	---	10	15	N-A, rich/red
Tin (Sn)	286.3	0.7	1.00	75	25.00	N-A, rich/red

**TABLE 1: Continued**

<b>Metal</b>	<b>WI (Nm)</b>	<b>Detec Slit (Nm)</b>	<b>Sens Limit (mg/L)</b>	<b>Linear Check (mg/L)</b>	<b>Range (mg/L)</b>	<b>Flame Type Color</b>
Titanium (Ti)	364.3	0.2	1.00	40	25.00	N-A, rich/red
Tungsten (W)	400.9	0.2	0.5	225	337.5	N-A, rich/red
Uranium (U)	351.5	0.2	---	2750	4125	N-A, rich/red
Vanadium (V)	318.4	0.2	0.40	45	75.00	N-A, rich/red
Ytterbium (Yb)	398.8	0.2	---	2.5	3.75	N-A, rich/red
Yttrium (Y)	410.2	0.2	---	40	60	N-A, rich/red
Zinc (Zn)	213.9	0.7	0.005	0.50	2.50	A-A, lean/blue
Zirconium (Zr)	360.1	0.2	---	150	225	N-A, rich/red

**NOTE:** The notations refer to preferred technique where FAAS is generally not suitable: *hg* means hydride technique; *cv* means cold vapor technique

**TABLE 2: Alternate Wavelengths**

	<b>WI</b>	<b>Slit</b>	<b>Rs</b>		<b>WI</b>	<b>Slit</b>	<b>Rs</b>
Aluminum	396.2	0.7	1.1	Gadolinium	407.9	0.2	1.0
	308.2	0.7	1.6		378.3	0.2	1.1
Antimony	206.8	0.2	1.5		405.8	0.2	1.2
	231.2	0.2	2.1		405.4	0.2	1.3
Arsenic	189.0	0.7	0.8		371.4	0.2	1.7
	197.2	0.7	2.0		419.1	0.2	2.7
Barium	350.1	0.2	16.0		367.4	0.2	2.9
Beryllium	none				404.5	0.2	3.2
Bismuth	222.8	0.2	2.4		394.6	0.2	6.5
	306.8	0.7	3.7	Gallium	294.4	0.7	1.0
	206.2	0.2	8.6		417.2	0.7	1.4
	227.7	0.2	14.0		250.0	0.7	9.0
			245.0		0.7	9.6	
Boron	none				272.0	0.7	20
Cadmium	326.1	0.7	435		259.2	0.2	2.2
Calcium	239.9	0.7	120	Germanium	271.0	0.2	2.4
Cesium	455.5	2.0	85				
	Chromium	359.4	0.7	1.7		275.5	0.2
	360.5	0.7	2.2		269.1	0.2	3.8
	425.4	0.7	3.0	Gold	267.6	0.7	1.8
	427.5	0.7	3.8		312.3	0.7	900
	429.0	0.7	4.5	Hafnium	307.3	0.2	
Cobalt	242.5	0.2	1.2		289.8	0.2	
	241.2	0.2	1.8		296.5	0.2	
	252.1	0.2	2.0	Holmium	405.4	0.2	1.3
	243.6	0.2	2.9		416.3	0.2	1.7
	304.4	0.2	12		417.3	0.2	4.2
	352.7	0.2	22		404.1	0.2	5.2
	346.6	0.2	30		410.9	0.2	9.8

**TABLE 2: Continued**

	<b>Wl</b>	<b>Slit</b>	<b>Rs</b>		<b>Wl</b>	<b>Slit</b>	<b>Rs</b>
Copper	327.4	0.7	2.0		412.7	0.2	11
	216.5	0.2	6.0		422.7	0.2	24
	222.6	0.2	15	Indium	325.6	0.2	1.0
	249.2	0.7	72		410.5	0.7	2.9
	224.4	0.2	157		451.1	0.7	3.1
Dysprosium	404.6	0.2	1.1		256.0	0.7	12
	418.7	0.2	1.2	Iridium	208.9	0.2	0.3
	419.5	0.2	1.6		266.5	0.2	1.2
Erbium	416.8	0.2	6.8		237.3	0.2	1.3
	386.3	0.2	2.7		285.0	0.2	1.4
	415.1	0.2	2.7		250.3	0.2	1.7
	389.3	0.2	5.0		254.4	0.2	2.1
	408.8	0.2	7.0		351.4	0.2	8.6
	381.0	0.2	8.4	Iron	248.8	0.2	1.7
	390.5	0.2	20		302.1	0.2	3.7
Europium	462.7	0.2	1.3		252.7	0.2	4.6
	466.2	0.2	1.5		372.0	0.2	5.7
	321.1	0.2	12		373.7	0.2	10
	321.3	0.2	15				
	311.1	0.2	15				
Lanthanum	418.7	0.2	1.6	Platinum	306.5	0.7	2.1
	495.0	0.2	1.7		283.0	0.2	3.4
	357.4	0.2	4.0		293.0	0.7	3.7
	365.0	0.2	4.0		273.4	0.2	4.1
	392.8	0.2	4.0	Potassium	769.9	0.7	2.3
Lead	217.0	0.7	0.4		Praseodymium	513.3	0.2
	261.4	0.7	10		473.7	0.2	2.2
	368.4	0.7	25		492.5	0.2	2.2
Lithium	323.3	0.7	235		502.7	0.2	2.5
Lutetium	331.2	0.2	1.8	Rhenium	346.5	0.2	1.7
	337.7	0.2	2.0		345.2	0.2	2.4
	356.8	0.2	2.1	Rhodium	369.2	0.2	1.7
	298.9	0.2	9.2		339.7	0.2	2.5
	451.9	0.2	11		350.2	0.2	3.7
Magnesium	202.6	0.7	24		365.8	0.2	6.0
Manganese	279.8	0.2	1.3	Rubidium	794.8	2.0	2.1
	280.1	0.2	1.9		420.2	0.7	120
	403.1	0.2	9.5	Ruthenium	372.8	0.2	1.4
Molybdenum	317.0	0.7	1.6		379.9	0.2	2.2
	379.8	0.7	1.8		392.6	0.2	11
	319.4	0.7	2.0	Samarium	476.0	0.2	1.4
	386.4	0.7	2.5		511.7	0.2	1.4
	390.3	0.7	3.3		520.1	0.2	1.6
	315.8	0.7	4.0		472.8	0.2	2.0

**TABLE 2: Continued**

	<b>Wl</b>	<b>Slit</b>	<b>Rs</b>		<b>Wl</b>	<b>Slit</b>	<b>Rs</b>
	320.9	0.2	8.7	Scandium	390.8	0.2	1.0
Neodymium	?				402.4	0.2	1.4
	?				402.0	0.2	1.8
	?				405.5	0.2	2.7
Nickel	231.1	0.2	1.5		327.0	0.2	3.2
	352.5	0.2	3.3		408.2	0.2	7.0
	341.5	0.2	3.5		327.4	0.2	12
	305.1	0.2	4.5	Selenium	204.0	0.2	3.0
	346.2	0.2	6.6		206.3	0.2	11
Niobium	358.0	0.2	1.1		207.5	0.2	35
	334.9	0.2	1.2	Silicon	250.7	0.7	2.8
	408.0	0.2	1.4		252.8	0.2	3.2
	335.8	0.2	1.5		252.4	0.2	3.7
	412.4	0.2	1.9		221.7	0.2	4.3
	357.6	0.2	2.5		221.1	0.2	8.0
Osmium	305.9	0.2	1.6	Silver	338.3	0.7	1.9
	263.7	0.2	1.8	Sodium	589.6	0.2	1.0
	301.8	0.2	3.2		330.2	2.0	185
	330.2	0.2	3.6	Strontium	none		
Palladium	247.6	0.2	1.0				
	276.3	0.2	2.7				
	340.5	0.2	3.0				
Phosphorus	214.9	0.2	2.0				
Tantalum	260.8	0.2	2.1	Tungsten	255.1	0.2	0.5
	265.7	0.2	2.5		294.4	0.2	0.7
	293.4	0.2	2.5		268.1	0.2	0.7
	255.9	0.2	2.5		272.4	0.2	0.7
	265.3	0.2	2.7		294.7	0.7	0.7
	269.8	0.2	2.7		283.1	0.2	1.0
	275.8	0.2	3.1		289.6	0.2	1.4
Technetium	260.9	0.2	4.1		287.9	0.2	2.4
	429.7	0.2	6.5		430.2	0.2	7.2
	426.2	0.2	8.1	Uranium	358.5	0.2	0.3
	318.2	0.2	10		356.7	0.2	0.5
	423.8	0.2	11	Vanadium	306.6	0.2	2.4
	363.6	0.2	11		306.0	0.2	2.4
	317.3	0.2	100		305.6	0.2	3.0
Tellurium	225.9	0.7	15		320.2	0.2	6.4
	238.6	0.7	50		390.2	0.2	6.5
Terbium	431.9	0.2	1.2	Ytterbium	346.4	0.2	3.5
	390.1	0.2	1.6		246.4	0.2	7.5
	406.2	0.2	1.8		267.2	0.2	40
	433.8	0.2	2.0	Yttrium	407.7	0.2	1.1
	410.5	0.2	3.6		412.8	0.2	1.2

**TABLE 2: Continued**

	<b>Wl</b>	<b>Slit</b>	<b>Rs</b>		<b>Wl</b>	<b>Slit</b>	<b>Rs</b>
Thallium	377.6	0.7	2.7		414.3	0.2	1.4
	238.0	0.2	6.7		362.1	0.2	2.0
	258.0	0.2	24	Zinc	307.6	0.7	4700
Thulium	410.6	0.2	1.4	Zirconium	354.8	0.2	1.5
	374.4	0.2	1.6		303.0	0.2	1.5
	409.4	0.2	1.7		301.2	0.2	1.7
	418.8	0.2	1.9		298.5	0.2	1.7
	420.4	0.2	3.0		362.4	0.2	1.9
	375.2	0.2	5.7				
	436.0	0.	9.3				
	341.0	0.2	14				
Tin	224.6	0.2	0.5	Titanium	365.4	0.2	1.0
	235.5	0.7	0.8		320.0	0.2	1.2
	270.6	0.7	2.0		363.6	0.2	1.2
	303.4	0.2	2.8		335.5	0.2	1.4
	254.7	0.7	4.4		375.3	0.2	1.6
	219.9	0.2	4.7		334.2	1.2	1.6
	300.9	0.7	5.9		399.9	0.2	1.6

## SECTION 8: Flame Techniques

### OVERVIEW

This section describes standard conditions for Flame Atomic Absorption Spectroscopy (FAAS) techniques. These techniques utilize combustion mixtures of either air-acetylene (A-A), nitrous oxide-acetylene (N-A) or argon-hydrogen (Ar-H). While nearly all elements can be determined in an A-A flame to some extent, this is often not the best type of flame to use. The flame mixtures given in this section are those which provide the greatest sensitivity for each element.

In order to provide good sensitivity, an optimal combustion mixture will have the following characteristics:

1. reaches an appropriate temperature for excitation of the analyte.
2. supplies chemical agents necessary to convert or stabilize the analyte in the atomic form.
3. reduces or eliminates spectral and/or chemical interferences.

The working temperature and ranges of the various flame types are given below, with the oxidizing gas ratio having the hottest temperature in each range. Both chemistry and temperature are influenced by the oxidant-to-fuel ratio. A fuel rich acetylene flame provides a highly reducing environment due to the excess amount of carbon radicals. This suppresses the ionization of easily oxidized elements and results in greater sensitivity for elements such as chromium and tin.

An oxidizing flame burns hotter than a reducing flame and creates less spectral interference in the near UV for elements such as nickel and zinc, which are not so easily ionized. The hotter temperature provides a greater proportion of excited atoms to the analysis, thereby increasing the sensitivity for these elements.

### *Characteristics of Different Combustion Mixtures*

<u><i>Oxidant</i></u>	<u><i>Fuel</i></u>	<u><i>Average Temp.</i></u>	<u><i>Temp. Range</i></u>
Air	Acetylene	2300	2120 to 2400
Nitrous Oxide	Acetylene	2750	2650 to 2800
Argon/Air	Hydrogen	400	350 to 1000

There are about 30 elements that form refractory oxides and cannot be dissociated in even the hottest air-acetylene flame. It is necessary then to use a nitrous oxide-acetylene flame for these elements. The N-A flame has the advantage of being able to decompose refractory compounds, but suffers from relatively higher noise caused by emission radiation from combustion by-products (CN, CH and NH). These by-products can also cause specific interferences with some elements where the emission spectrum overlaps an absorbing line. Sometimes this type of interference cannot be removed by any type of background correction, making analysis virtually impossible. In the very hot N-A flame, an ionization suppressant must be added to the sample (usually a potassium or lanthanum salt) to prevent the analyte from being lost to the analysis through ionization.

Elements with characteristic wavelengths near the start of the vacuum UV range show considerable improvement in sensitivity with an argon-hydrogen flame. It is not yet certain what atomization mechanisms occur, however, it is generally agreed that hydrogen has an active role in the process. Because of its very high transparency the Ar-H flame gives particularly good sensitivity for arsenic and selenium.

Other flame types have been investigated with varying results. In some cases a specific combustion mixture shows excellent sensitivity for one element, but there is little practicality in changing gases for each analyte. The A-A and N-A flames are consequently used in most laboratories because of their broad versatility.

Where arsenic and selenium determinations must be made, switching to the Ar-H flame is worth the effort. In its use, the analytes are determined by direct aspiration into the flame.

A more sensitive technique, hydride generation, doesn't require any modification of the combustion mixture. In this technique arsenic and selenium are converted to the arsine or selenine gas and swept into a quartz cell heated by the flame. The hydride technique is used when highest sensitivity for these elements is required. In this case an A-A flame is used, and merely serves as a convenient source of heat. Since elemental mercury has a significant vapor pressure at room temperatures, and is subject to numerous interferences even in a N-A flame, it is best performed using a flameless technique. Hydride generation and mercury determinations are discussed in Section 3.4 – Cold vapor/hydride Techniques.

## SECTION 9: Interferences

There are basically three categories of interferences that can occur in flame atomic absorption work, termed *physical*, *chemical*, and *spectral*. Chemical interference is most often encountered and is caused by lack of absorption of atoms bound in molecular combination in the flame. This occurs when the flame is not hot enough to dissociate the molecule. Phosphates interfere with magnesium, calcium and barium, and is overcome by adding lanthanum to the solution. Similarly, silica interferes in the determination of manganese and can be eliminated by the addition of calcium.

Chemical interferences may also be eliminated by separating the metal from the interfering material. Although complexing agents are employed primarily to increase the sensitivity of the analysis, they may also be used to eliminate or reduce interferences.

Highly refractory metal oxides, especially those of the rare earth metals, do not dissociate at the temperature of an air-acetylene flame. Other metals dissociated into the atomic state often recombine with oxygen in the flame so rapidly that further atomization is not possible. In these cases an alternate combustion mixture is used, most often a nitrous oxide-acetylene flame, to provide greater heat for decomposition.

If an element in the atomic state becomes ionized in the flame, its absorption spectra will change, effectively removing it from the analysis. The fraction of ionized atoms in the flame increases with increased temperature, and at the heat of a nitrous oxide-acetylene flame nearly all elements are significantly ionized. This type of interference is most pronounced for elements such as barium, which is readily ionized but requires high temperature excitation for analysis at the usual concentration range. Ionization can generally be controlled by the addition of a large excess (>1,000 mg/L) of an easily ionized element such as K, Na, Li or Cs to the sample.

All metals are not equally stable in a digested solution, especially if it contains only nitric acid, and not nitric and hydrochloric acids together. The digestate should be analyzed as soon as possible, with preference given to antimony, barium, molybdenum, silver and tin.

High concentrations of dissolved solids in the sample may result in an interference from physical (non-atomic) absorbance such as light scattering. If background correction is not used, the sample can be re-analyzed at a nearby, non-specific wavelength\*. If absorbance is found at this wavelength, it is due to a physical effect and the sample should be treated by a filtration, digestion or extraction procedure to remove the interference.

\* All hollow cathode lamps emit not only the line spectra of the element comprising the cathode, but also that of the fill gas and other incidental impurities; therefore, it is always possible to find an energetic line somewhere near the resonant wavelength of the element of interest which will not respond to the element, but will respond to physical interferences.



Spectral interference can occur when an absorbing wavelength of an element present in the sample but not being determined falls within the width of the absorption line of the element of interest. The results of the determination will then be erroneously high, due to the contribution of the interfering element to the atomic absorption signal. Interference can also occur when resonant energy from another element in a multi-element lamp, or from a metal impurity in the lamp cathode, falls within the bandpass of the slit setting when that other metal is present in the sample. This type of interference may sometimes be reduced by narrowing the slit width.

Samples and standards should be monitored for viscosity differences that may alter the aspiration rate.

Molecular spectra of certain common compounds have broad absorption profiles and can produce a positive interference; that is, the measured absorbance is greater than the actual absorbance of the analyte. The table below illustrates some common molecular absorbance bands:

**Table 3: Overlapping Spectra of Some Common Analytes** (Source: Norris & West; *Analytical Chemistry*; 1974, V46, p. 1423).

<u>Analyte</u>	<u>Wavelength</u>	<u>Overlapping Element</u>	<u>Wavelength</u>
Aluminum	396.15	Fe	396.11
Bismuth	206.17	I	206.16
Calcium	422.67	Ge	422.66
Cadmium	228.80	As	228.81
Chromium	359.35	Hg	359.35
		Ne	359.35
Copper	217.89	Sb	217.92
	324.75	Fe	324.73
	324.75	Eu	324.75
	327.40	Fe	327.45
Cobalt	253.65	Hg	253.65
	241.16	Pb	241.17
Iron	213.86	Zn	213.86
Lead	217.00	Sb	217.02
Lithium	323.26	Sb	323.25
Magnesium	285.21	Fe	285.21
	285.21	Hg	285.24
Manganese	279.48	Fe	279.47
	403.31	Ga	403.30
Mercury	253.65	Co	253.65
Nickel	231.10	Sb	213.15
	352.45	Fe	352.43
Palladium	247.64	Pb	247.64
Platinum	271.90	Fe	271.90
Silver	338.29	Fe	338.24
Strontium	460.73	Fe	460.77
Vanadium	250.69	Si	250.69
	308.21	Al	308.22
Zinc	213.86	Fe	213.86

## SECTION 10: Method of Standard Additions

If methods of standard addition are required, the following procedure is recommended.

**SA.1** The standard addition techniques involves preparing new standards in the sample matrix by adding known amounts of standard to one or more aliquots of the processed sample solution. This technique compensates for a sample constituent that enhances or depresses the analyte signal thus producing a different slope from that of the calibration standards. It will not correct for additive interference which causes a baseline shift. The simplest version of this technique is the single-addition method. The procedure is as follows. Two identical aliquots of the sample solution, each of volume  $V_x$ , are taken. To the first (labeled A) is added a small volume  $V_a$  of a standard analyte solution of concentration  $c_s$ . To the second (labeled B) is added the same volume  $V_s$ , of the solvent. The analytical signals of A and B are measured and corrected for nonanalyte signals. The unknown sample concentration  $c_x$  is calculated:

$$c(x) = \frac{S(B) V(s) c(s)}{(S(A) - S(B))V_x}$$

where  $S(A)$  and  $S(B)$ , are the analytical signals (corrected for the blank) of solutions A and B, respectively.

$V_s$ , and  $c_s$ , should be chosen so that  $S(A)$  is roughly twice  $S(B)$  on the average. It is best if  $V_s$ , is made much less than  $V_x$ , and thus  $c_s$ , is much greater than  $C_x$ , to avoid excess dilution of the sample matrix. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure. For the results from this technique to be valid, the following limitations must be taken into consideration:

1. The analytical curve must be linear.
2. The chemical form of the analyte added must respond the same as the analyte in the sample.
3. The interference effect must be constant over the working range of concern.

When greater accuracy is required, the following method of standard addition is recommended:

**SA.2** Add equal volumes of deionized water and three standards containing different amounts of the test element to 4 aliquots of the sample. The aliquots must also be of equal volume. Determine the absorbance of each solution and plot as shown below. The concentration of the standards is taken as the  $X$  value, with the sample assigned the value  $X=0$ . When the resulting line is extrapolated back to zero absorbance, the point of intersection with the horizontal axis is the concentration of the unknown.

*(courtesy of BUCK SCIENTIFIC, Inc. Applications Department, Norwalk, Ct).*

The method of standard addition is subject to certain limitations, which must be taken into consideration when examining the results. The curve must be within the liner range of the analysis. For the best results, the slope of the curve should be nearly the same as that of the standards alone. The diagram above shows a typical relationship between the sample analysis (upper curve) and the curve of the standard solutions.

If the slope of the standard addition curve differs by more than 20% of the standard curve, the results are suspect. In addition, the effect of interferences should not vary with concentration of the analyte or other components in solution. Spectral interferences are not corrected for by this method; use suitable background correction (i.e., deuterium, giant pulse, etc.).

Graphing the results enables the analyst to visually determine the validity of the results by checking for linearity, and by comparison with a curve of the standard solutions; however it leads to some uncertainty in determining the concentration of the unknown. For the highest precision, the unknown should be determined by calculation from:

$$[u] = 0.25\{(\sum x) - \frac{[4\sum x^2 - (\sum x)^2]}{[4\sum x\sum xy - \sum x\sum y]}\}$$

where: [u] is concentration of unknown

$\sum$  means "sum"

y is an absorbance value for each corresponding concentration, x

## Compatible printers

Canon BJ-30	Canon S900	Epson Artisan 700
Canon BJC-50	Canon S9000	Epson Artisan 710
Canon BJC-55	Canon S4500	Epson Artisan 800
Canon BJC-80	Canon SELPHY DS700	Epson Artisan 810
Canon BJC-85	Canon SELPHY DS810	Epson Artisan 835
Canon BJC-210	Canon PIXMA mini220	Epson B-300
Canon BJC-240	Canon PIXUS mini220	Epson B-308
Canon BJC-250	Canon PIXMA mini320	Epson B-310
Canon BJC-1000	Canon PIXMA mini360	Epson B-310N
Canon BJC-2000	Canon PIXUS mini360	Epson B-500DN
Canon BJC-2010	Canon iP90 series	Epson B-508DN
Canon BJC-2100	Canon PIXMA iP90	Epson B-510DN
Canon BJC-2110	Canon PIXUS iP90	Epson L120
Canon BJC-3000	Canon PIXMA iP90v	Epson L210
Canon BJC-4000	Canon PIXUS iP90v	Epson L1300
Canon BJC-4300	Canon iP100 series	Epson L1800
Canon BJC-4400	Canon PIXMA iP100	Epson Stylus C20
Canon BJC-4550	Canon PIXUS iP100	Epson Stylus C20SX
Canon BJC-5100	Canon PIXMA iP4000	Epson Stylus C20UX
Canon BJC-5500	Canon PIXMA iP4000R	Epson Stylus C40
Canon BJC-5500J	Canon PIXUS 50i	Epson Stylus C40SX
Canon BJC-6000	Canon PIXUS 80i	Epson Stylus C40UX
Canon BJC-6100	Canon PIXUS 450i	Epson Stylus C41
Canon BJC-6200	Canon PIXUS 455i	Epson Stylus C41SX
Canon BJC-6500	Canon PIXUS 470PD	Epson Stylus C41UX
Canon BJC-7000	Canon PIXUS 475PD	Epson Stylus C42
Canon BJC-7100	Canon PIXUS 550i	Epson Stylus C42SX
Canon BJC-8200	Canon PIXUS 560i	Epson Stylus C42UX
Canon BJC-8500	Canon PIXUS 850i	Epson Stylus C43
Canon S100	Canon PIXUS 860i	Epson Stylus C43SX
Canon S200	Canon PIXUS 865R	Epson Stylus C43UX
Canon S300	Canon PIXUS 900PD	Epson Stylus C44
Canon S330	Canon PIXUS 950i	Epson Stylus C44SX
Canon S400	Canon PIXUS 960i	Epson Stylus C44UX
Canon S450	Canon PIXUS 990i	Epson Stylus C45
Canon S500	Canon PIXUS 6100i	Epson Stylus C46
Canon S520	Canon PIXUS 6500i	Epson Stylus C48
Canon S530D	Canon PIXUS 9100i	Epson Stylus C50
Canon S600	Canon PIXUS 9900i	Epson Stylus C60
Canon S630	Canon i70	Epson Stylus C61
Canon S750	Canon i80	Epson Stylus C62
Canon S800	Canon i450	Epson Stylus C63
Canon S820	Canon i6100	Epson Stylus C64
Canon S830D	Canon i6500	Epson Stylus C65
	Canon i9100	Epson Stylus C66
	Epson Artisan 50	Epson Stylus C68

Epson Stylus C70	Epson Stylus Office B40W	Epson Stylus Photo 1280
Epson Stylus C79	Epson Stylus Office B42WD	Epson Stylus Photo 1290
Epson Stylus C80	Epson Stylus Office B1100	Epson Stylus Photo 1290s
Epson Stylus C82	Epson Stylus Office T30	Epson Stylus Photo 1400
Epson Stylus C83	Epson Stylus Office T33	Epson Stylus Photo 1410
Epson Stylus C84	Epson Stylus Office T40W	Epson Stylus Photo 2000P
Epson Stylus C85	Epson Stylus Office T1100	Epson Stylus Photo 2100
Epson Stylus C86	Epson Stylus Office T1110	Epson Stylus Photo 2200
Epson Stylus C87	Epson Stylus Office BX300F	Epson Stylus Photo P50
Epson Stylus C88	Epson Stylus Office BX525WD	Epson Stylus Photo R200
Epson Stylus C92	Epson Stylus Office BX535WD	Epson Stylus Photo R210
Epson Stylus C110	Epson Stylus Office BX600FW	Epson Stylus Photo R220
Epson Stylus C120	Epson Stylus Office BX625FWD	Epson Stylus Photo R230
Epson Stylus Color	Epson Stylus Office BX630FW	Epson Stylus Photo R240
Epson Stylus Color I	Epson Stylus Office BX635FWD	Epson Stylus Photo R245
Epson Stylus Color II	Epson Stylus Office SX600FW	Epson Stylus Photo R260
Epson Stylus Color IIs	Epson Stylus Office SX620FW	Epson Stylus Photo R265
Epson Stylus Color PRO	Epson Stylus Office TX300F	Epson Stylus Photo R270
Epson Stylus Pro XL	Epson Stylus Office TX600FW	Epson Stylus Photo R280
Epson Stylus Color 400	Epson Stylus Office TX620FWD	Epson Stylus Photo R285
Epson Stylus Color 440	Epson Stylus Photo	Epson Stylus Photo R290
Epson Stylus Color 460	Epson Stylus Photo 700	Epson Stylus Photo R300
Epson Stylus Color 480	Epson Stylus Photo EX	Epson Stylus Photo R310
Epson Stylus Color 500	Epson Stylus Photo EX3	Epson Stylus Photo R320
Epson Stylus Color 580	Epson Stylus Photo 720	Epson Stylus Photo R340
Epson Stylus Color 600	Epson Stylus Photo 750	Epson Stylus Photo R350
Epson Stylus Color 640	Epson Stylus Photo 780	Epson Stylus Photo R360
Epson Stylus Color 660	Epson Stylus Photo 785	Epson Stylus Photo R380
Epson Stylus Color 670	Epson Stylus Photo 790	Epson Stylus Photo R390
Epson Stylus Color 680	Epson Stylus Photo 810	Epson Stylus Photo R800
Epson Stylus Color 740	Epson Stylus Photo 820	Epson Stylus Photo R1800
Epson Stylus Color 760	Epson Stylus Photo 825	Epson Stylus Photo R1900
Epson Stylus Color 777	Epson Stylus Photo 830	Epson Stylus Photo R2000
Epson Stylus Color 800	Epson Stylus Photo 830U	Epson Stylus Photo R2400
Epson Stylus Color 850	Epson Stylus Photo 870	Epson Stylus Photo R2880
Epson Stylus Color 860	Epson Stylus Photo 875	Epson Stylus Photo R3000
Epson Stylus Color 880	Epson Stylus Photo 890	Epson Stylus Photo RX400
Epson Stylus Color 8 3	Epson Stylus Photo 895	Epson Stylus Photo RX420
Epson Stylus Color 900	Epson Stylus Photo 900	Epson Stylus Photo RX425
Epson Stylus Color 980	Epson Stylus Photo 915	Epson Stylus Photo RX430
Epson Stylus Color 1160	Epson Stylus Photo 925	Epson Stylus Photo RX500
Epson Stylus Color 1500	Epson Stylus Photo 935	Epson Stylus Photo RX510
Epson Stylus Color 1520	Epson Stylus Photo 950	Epson Stylus Photo RX560
Epson Stylus Color 3000	Epson Stylus Photo 960	Epson Stylus Photo RX580
Epson Stylus Office B30	Epson Stylus Photo 1200	Epson Stylus Photo RX585
Epson Stylus Office B33	Epson Stylus Photo 1270	Epson Stylus Photo RX590

Epson Stylus Photo RX595	Epson Stylus CX1500	Epson Stylus D78
Epson Stylus Photo RX600	Epson Stylus CX3100	Epson Stylus D88
Epson Stylus Photo RX610	Epson Stylus CX3200	Epson Stylus D92
Epson Stylus Photo RX620	Epson Stylus CX3500	Epson Stylus D120
Epson Stylus Photo RX630	Epson Stylus CX3600	Epson Stylus DX3800
Epson Stylus Photo RX640	Epson Stylus CX3650	Epson Stylus DX3850
Epson Stylus Photo RX650	Epson Stylus CX3700	Epson Stylus DX4000
Epson Stylus Photo RX680	Epson Stylus CX3800	Epson Stylus DX4050
Epson Stylus Photo RX685	Epson Stylus CX3805	Epson Stylus DX4200
Epson Stylus Photo RX690	Epson Stylus CX3810	Epson Stylus DX4250
Epson Stylus Photo RX700	Epson Stylus CX3900	Epson Stylus DX4400
Epson Stylus Photo TX700W	Epson Stylus CX4100	Epson Stylus DX4450
Epson Stylus Photo TX710W	Epson Stylus CX4200	Epson Stylus DX4800
Epson Stylus Photo TX800FW	Epson Stylus CX4400	Epson Stylus DX4850
Epson Stylus Photo TX810FW	Epson Stylus CX4500	Epson Stylus DX7000F
Epson Stylus Pro 3800	Epson Stylus CX4600	Epson Stylus DX7400
Epson Stylus Pro 3880	Epson Stylus CX4700	Epson Stylus DX7450
Epson Stylus Pro 3885	Epson Stylus CX4800	Epson Stylus DX8400
Epson Stylus Pro 4000	Epson Stylus CX4900	Epson Stylus DX8450
Epson Stylus Pro 4800/4880 Back Compatible	Epson Stylus CX5000	Epson Stylus DX9400F
Epson Stylus Pro 4800	Epson Stylus CX5000F	Epson Stylus NX100
Epson Stylus Pro 4880	Epson Stylus CX5100	Epson Stylus NX105
Epson Stylus Pro 5000	Epson Stylus CX5200	Epson Stylus NX115
Epson Stylus Pro 5500	Epson Stylus CX5300	Epson Stylus NX200
Epson Stylus Pro 7000	Epson Stylus CX5400	Epson Stylus NX215
Epson Stylus Pro 7500	Epson Stylus CX5500	Epson Stylus NX300
Epson Stylus Pro 7600	Epson Stylus CX5600	Epson Stylus NX400
Epson Stylus Pro 7700	Epson Stylus CX5700	Epson Stylus NX415
Epson Stylus Pro 7800	Epson Stylus CX5800	Epson Stylus NX420
Epson Stylus Pro 7880	Epson Stylus CX6000	Epson Stylus NX515
Epson Stylus Pro 7890	Epson Stylus CX6300	Epson Stylus NX530
Epson Stylus Pro 7900	Epson Stylus CX6400	Epson Stylus NX625
Epson Stylus Pro 9000	Epson Stylus CX6500	Epson Stylus NX630
Epson Stylus Pro 9500	Epson Stylus CX6600	Epson Stylus NX635
Epson Stylus Pro 9600	Epson Stylus CX7000F	Epson Stylus NX645
Epson Stylus Pro 9700	Epson Stylus CX7300	Epson Stylus Photo PX650
Epson Stylus Pro 9800	Epson Stylus CX7400	Epson Stylus Photo PX700W
Epson Stylus Pro 9880	Epson Stylus CX7700	Epson Stylus Photo PX710W
Epson Stylus Pro 9890	Epson Stylus CX7800	Epson Stylus Photo PX800FW
Epson Stylus Pro 9900	Epson Stylus CX8300	Epson Stylus Photo PX810FW
Epson Stylus Pro 10000	Epson Stylus CX8400	Epson Stylus S20
Epson Stylus Pro 11800/11880 Back Compatible	Epson Stylus CX9300F	Epson Stylus S21
Epson Stylus Pro 11800	Epson Stylus CX9400	Epson Stylus S50
Epson Stylus Pro 11880	Epson Stylus CX9400F	Epson Stylus SX100
Epson Stylus Scan 2000	Epson Stylus CX9475F	Epson Stylus SX105
Epson Stylus Scan 2500	Epson Stylus D68	Epson Stylus SX110

Epson Stylus SX115	Epson Stylus TX300F	Epson WorkForce 645
Epson Stylus SX200	Epson Stylus TX400	Epson WorkForce 1100
Epson Stylus SX205	Epson Stylus TX410	Epson CL 700
Epson Stylus SX210	Epson Stylus TX420	Epson CL 750
Epson Stylus SX215	Epson Stylus TX510FN	Epson CL 760
Epson Stylus SX400	Epson Stylus TX550W	Epson E 100
Epson Stylus SX405	Epson Stylus TX560WD	Epson E 150
Epson Stylus SX410	Epson Stylus TX610FW	Epson E 200
Epson Stylus SX415	Epson Stylus TX615	Epson E 300
Epson Stylus SX420	Epson Stylus TX630	Epson E 500
Epson Stylus SX445W	Epson Stylus TX635	Epson E 520
Epson Stylus SX510W	Epson Stylus TX645	Epson E 700
Epson Stylus SX515	Epson Stylus TX650	Epson E 720
Epson Stylus SX525	Epson Stylus TX659	Epson EM 900C
Epson Stylus SX535FW	Epson PictureMate	Epson EM 930C
Epson Stylus SX600FW	Epson PictureMate Dash	Epson EP 302
Epson Stylus SX610FW	Epson PictureMate Deluxe	Epson EP 702A
Epson Stylus SX615	Epson PictureMate Flash	Epson EP 801A
Epson Stylus SX630	Epson PictureMate Pal	Epson EP 901A
Epson Stylus SX635	Epson PictureMate Snap	Epson EP 901F
Epson Stylus SX645	Epson PictureMate 100	Epson MC 2000
Epson Stylus SX650	Epson PictureMate 200	Epson MC 5000
Epson Stylus T13	Epson PictureMate 210	Epson MC 7000
Epson Stylus T20	Epson PictureMate 215	Epson MC 9000
Epson Stylus T21	Epson PictureMate 240	Epson MC 10000
Epson Stylus T22	Epson PictureMate 250	Epson ME 300
Epson Stylus T22E	Epson PictureMate 260	Epson ME 320
Epson Stylus T26	Epson PictureMate 270	Epson ME Office 70
Epson Stylus T30	Epson PictureMate 280	Epson ME Office 80W
Epson Stylus T40W	Epson PictureMate 290	Epson ME Office 82WD
Epson Stylus T42WD	Epson PictureMate 500	Epson ME Office 85ND
Epson Stylus T50	Epson PictureMate 2005	Epson ME Office 360
Epson Stylus T59	Epson WorkForce 30	Epson ME Office 600F
Epson Stylus T60	Epson WorkForce 40	Epson ME Office 620F
Epson Stylus TX100	Epson WorkForce 60	Epson ME Office 700FW
Epson Stylus TX101	Epson WorkForce 310	Epson ME Office 900WD
Epson Stylus TX102	Epson WorkForce 315	Epson ME Office 940FW
Epson Stylus TX103	Epson WorkForce 500	Epson ME Office 960FWD
Epson Stylus TX104	Epson WorkForce 545	Epson ME Office 1100
Epson Stylus TX105	Epson WorkForce 600	Epson MJ 930C
Epson Stylus TX106	Epson WorkForce 610	Epson MJ 5100C
Epson Stylus TX109	Epson WorkForce 615	Epson MJ 6000C
Epson Stylus TX110	Epson WorkForce 625	Epson MJ 8000C
Epson Stylus TX125	Epson WorkForce 630	Epson PM 670C
Epson Stylus TX200	Epson WorkForce 633	Epson PM 700C
Epson Stylus TX210	Epson WorkForce 635	Epson PM 730C

Epson PM 740C	Epson PM G4500	Brother HL-10V
Epson PM 750C	Epson PX A650	Brother HL-10h
Epson PM 760C	Epson Offirio PX B300	Brother HL-1240
Epson PM 770C	Epson Offirio PX B500	Brother HL-1250
Epson PM 780C	Epson PX 7V	Brother HL-1260
Epson PM 790PT	Epson PX 101	Brother HL-1270N
Epson PM 800C	Epson PX 201	Brother HL-1440
Epson PM 850PT	Epson PX 203	Brother HL-1450
Epson PM 870C	Epson PX 204	Brother HL-1470N
Epson PM 880C	Epson PX 401A	Brother HL-1650
Epson PM 930C	Epson PX 503A	Brother HL-1660e
Epson PM 940C	Epson PX 504A	Brother HL-1670N
Epson PM 950C	Epson PX 601F	Brother HL-1850
Epson PM 970C	Epson PX 603F	Brother HL-1870N
Epson PM 980C	Epson PX 1001	Brother HL-2030
Epson PM 2000C	Epson PX G900	Brother HL-2035
Epson PM 2200C	Epson PX G920	Brother HL-2060
Epson PM 3000C	Epson PX G5000	Brother HL-2250DN
Epson PM 3300C	Epson PX G5300	Brother HL-2460
Epson PM 3500C	Epson PX V500	Brother HL-2460N
Epson PM 3700C	Epson PX V600	Brother HL-4Ve
Epson PM 4000PX	Epson PX V630	Brother HL-5030
Epson PM 5000C	Epson PX V780	Brother HL-5040
Epson PM 7000C	Epson PX 5500	Brother HL-5050
Epson PM 9000C	Epson PX G5600	Brother HL-5070N
Epson PM 10000	Epson PX 7000	Brother HL-5140
Epson PM A650	Epson PX 9000	Brother HL-5150D
Epson PM A750	Epson XP-820	Brother HL-5170DN
Epson PM A820	Apollo P-2100	Brother HL-630
Epson PM A890	Apollo P-2150	Brother HL-660
Epson PM A900	Apollo P-2200	Brother HL-7050
Epson PM A940	Apollo P-2250	Brother HL-7050N
Epson PM A950	Apollo P-2500	Brother HL-760
Epson PM D600	Apollo P-2550	Brother HL-960
Epson PM D750	Apollo P-2600	Brother MFC-6550MC
Epson PM D770	Apollo P-2650	Brother MFC-8300
Epson PM D800	Apple Color StyleWriter 4100	Brother MFC-9500
Epson PM D870	Apple Color StyleWriter 4500	Brother MFC-9600
Epson PM D1000	Apple Color StyleWriter 6500	Canon GP 335
Epson PM G700	Apple LaserWriter Select 360	Canon LBP-4sx
Epson PM G720	Brother DCP-1200	Canon LBP-430
Epson PM G730	Brother DCP-8045D	Canon LBP-1000
Epson PM G800	Brother HL-1040	Canon LBP-1260
Epson PM G820	Brother HL-1050	Canon LBP-1760
Epson PM G850	Brother HL-1060	Canon LBP-3360
Epson PM T960	Brother HL-1070	Canon imageRunner 330s



Citizen ProJet II	Generic PCL 5 Printer wide margin	Gestetner MP4500/DSm745e
Datamax-ONeil p1115	Generic PCL 5 LF Printer	Gestetner MP5500/DSm755
Datamax-ONeil p1115s	Generic PCL 5c Printer	Gestetner MP6500/DSm765
Datamax-ONeil p1120n	Generic PCL 5c LF Printer	Gestetner MP7500/DSm775
Datamax-ONeil p1125	Generic PCL 5e Printer	Gestetner MP9000/DSm790
Datamax-ONeil p1725	Generic PCL 5e LF Printer	Gestetner MP 161/DSm416
Datamax-ONeil w1110	Generic PCL 6/PCL XL Printer	Gestetner MP 2510/DSm725e
Datamax-ONeil H8308p	Generic PCL 6/PCL XL LF Printer	Gestetner MP 2550
DEC 1800	Generic PCL 6 Printer wide margin	Gestetner MP 2550B
DEC LN17	Generic PCL 6 LF Printer wide margin	Gestetner MP 3010/DSm730e
Epson ActionLaser 1100	Generic PCL 6 Tabl Printer wide margin	Gestetner MP 3350
Epson ActionLaser II	Gestetner 10512	Gestetner MP 3350B
Epson AL-C2000	Gestetner 2212	Gestetner MP 4000
Epson AL-C2000 PS3	Gestetner 2712	Gestetner MP 4000B
Epson AL-C8500	Gestetner 3212	Gestetner MP 5000
Epson AL-C8500PS	Gestetner 3502	Gestetner MP 5000B
Epson AL-C8600	Gestetner 3532/4235g	HP Business Inkjet 2200
Epson AL-C8600 PS3	Gestetner 4502	HP Business Inkjet 2230
Epson EPL-5200	Gestetner 4532/4245g	HP Business Inkjet 2250
Epson EPL-5200+	Gestetner 6002	HP Business Inkjet 2250TN
Epson EPL-5700	Gestetner 7502	HP Business Inkjet 2280
Epson EPL-5700PS	Gestetner 9002	HP Color Inkjet Printer CP1160
Epson EPL-5800	Gestetner DSm415	HP Color Inkjet Printer CP1700
Epson EPL-5800PS	Gestetner DSm615	HP Color LaserJet 2500
Epson EPL-5900	Gestetner DSm616	HP Color LaserJet 4500
Epson EPL-5900 PS3	Gestetner DSm618	HP Color LaserJet 4550
Epson EPL-6100	Gestetner DSm618d	HP Color LaserJet 4600
Epson EPL-6100 PS3	Gestetner DSm620	HP Color LaserJet 5
Epson EPL-7100	Gestetner DSm620d	HP Color LaserJet 5000
Epson EPL-N2050	Gestetner DSm622	HP Color LaserJet 5500
Epson EPL-N2050+	Gestetner DSm627	HP Color LaserJet 8550GN
Epson EPL-N2050PS	Gestetner DSm635/635G	HP DesignJet 230
Epson EPL-N2050PS+	Gestetner DSm645/645G	HP DesignJet 250C
Epson EPL-N2120	Gestetner DSm651	HP DesignJet 430
Epson EPL-N2500	Gestetner DSm660	HP DesignJet 450C
Epson EPL-N2500 PS3	Gestetner DSm675	HP DesignJet 455CA
Epson EPL-N2750	Gestetner DSm725	HP DesignJet 488CA
Epson EPL-N2750PS	Gestetner DSm730	HP DesignJet 700
Fujitsu PrintPartner 10V	Gestetner DSm735/735G	HP DesignJet 750C Plus
Fujitsu PrintPartner 16DV	Gestetner DSm745/745G	HP DesignJet 750C
Fujitsu PrintPartner 20W	Gestetner MP1100/DSm7110	HP DesignJet 2500CP
Fujitsu PrintPartner 8000	Gestetner MP1350/DSm7135	HP DesignJet 3500CP
Generic PCL 4 Printer	Gestetner MP1600/DSm716	HP DesignJet ColorPro CAD
Generic PCL 4 Printer wide margin	Gestetner MP2000/DSm721d	HP DeskJet 400
Generic PCL 4 LF Printer	Gestetner MP2500/DSm625	HP DeskJet 420C
Generic PCL 5 Printer	Gestetner MP3500/DSm735e	HP DeskJet 450

HP DeskJet 500	HP DeskJet 880C	HP LaserJet 3P w/ PCL5
HP DeskJet 500C	HP DeskJet 882C	HP LaserJet 3P w/PS
HP DeskJet 505J Plus	HP DeskJet 890C	HP LaserJet 4 Plus
HP DeskJet 510	HP DeskJet 895C	HP LaserJet 4
HP DeskJet 520	HP DeskJet 916C	HP LaserJet 4L
HP DeskJet 540C	HP DeskJet 920C	HP LaserJet 4M
HP DeskJet 550C	HP DeskJet 9300	HP LaserJet 4ML
HP DeskJet 5550	HP DeskJet 930C	HP LaserJet 4P
HP DeskJet 5551	HP DeskJet 932C	HP LaserJet 4Si
HP DeskJet 560C	HP DeskJet 933C	HP LaserJet 4V
HP DeskJet 600	HP DeskJet 934C	HP LaserJet 5
HP DeskJet 600C	HP DeskJet 935C	HP LaserJet 5L
HP DeskJet 610C	HP DeskJet 940C	HP LaserJet 5M
HP DeskJet 610CL	HP DeskJet 948C	HP LaserJet 5MP
HP DeskJet 6122	HP DeskJet 950C	HP LaserJet 5P
HP DeskJet 6127	HP DeskJet 952C	HP LaserJet 5Si
HP DeskJet 612C	HP DeskJet 955C	HP LaserJet 6
HP DeskJet 640C	HP DeskJet 957C	HP LaserJet 6L
HP DeskJet 648C	HP DeskJet 959C	HP LaserJet 6MP
HP DeskJet 660C	HP DeskJet 960C	HP LaserJet 6P
HP DeskJet 670C	HP DeskJet 970C	HP LaserJet 1010
HP DeskJet 670TV	HP DeskJet 975C	HP LaserJet 1012
HP DeskJet 672C	HP DeskJet 980C	HP LaserJet 1015
HP DeskJet 680C	HP DeskJet 990C	HP LaserJet 1022
HP DeskJet 682C	HP DeskJet 995C	HP LaserJet 1100
HP DeskJet 690C	HP DeskJet 1100C	HP LaserJet 1100A
HP DeskJet 692C	HP DeskJet 1120C	HP LaserJet 1150
HP DeskJet 693C	HP DeskJet 1125C	HP LaserJet 1160
HP DeskJet 694C	HP DeskJet 1200C	HP LaserJet 1200
HP DeskJet 695C	HP DeskJet 1220C	HP LaserJet 1220
HP DeskJet 697C	HP DeskJet 1600C	HP LaserJet 1300
HP DeskJet 810C	HP DeskJet 1600CM	HP LaserJet 1320
HP DeskJet 812C	HP DeskJet 2000	HP LaserJet 2100
HP DeskJet 815C	HP DeskJet 2500	HP LaserJet 2100M
HP DeskJet 816C	HP DeskJet 2500CM	HP LaserJet 2200
HP DeskJet 825C	HP DeskJet 340C	HP LaserJet 2300
HP DeskJet 830C	HP DeskJet 3810	HP LaserJet 2410
HP DeskJet 832C	HP DeskJet 3816	HP LaserJet 2420
HP DeskJet 840C	HP DeskJet 3820	HP LaserJet 2430
HP DeskJet 841C	HP DeskJet 3822	HP LaserJet 3015
HP DeskJet 842C	HP LaserJet 2	HP LaserJet 3020
HP DeskJet 843C	HP LaserJet 2D	HP LaserJet 3030
HP DeskJet 845C	HP LaserJet 2P Plus	HP LaserJet 3050
HP DeskJet 850C	HP LaserJet 2P	HP LaserJet 3052
HP DeskJet 855C	HP LaserJet 3	HP LaserJet 3055
HP DeskJet 870C	HP LaserJet 3D	HP LaserJet 3200

HP LaserJet 3200m	HP OfficeJet 520	HP PSC 380
HP LaserJet 3200se	HP OfficeJet 570	HP PSC 500
HP LaserJet 3300 MFP	HP OfficeJet 580	HP PSC 750
HP LaserJet 3310 MFP	HP OfficeJet 590	HP PSC 950
HP LaserJet 3320 MFP	HP OfficeJet 600	HP PSC 950xi
HP LaserJet 3320N MFP	HP OfficeJet 610	HP PSC 2110
HP LaserJet 3330 MFP	HP OfficeJet 625	HP PSC 2150
HP LaserJet 3380	HP OfficeJet 630	HP PSC 2210
HP LaserJet 3390	HP OfficeJet 635	HP PhotoSmart 7150
HP LaserJet 3392	HP OfficeJet 700	HP PhotoSmart 7345
HP LaserJet 4000	HP OfficeJet 710	HP PhotoSmart 7350
HP LaserJet 4050	HP OfficeJet 720	HP PhotoSmart 7550
HP LaserJet 4100	HP OfficeJet 725	HP PhotoSmart P100
HP LaserJet 4200	HP OfficeJet 5105	HP PhotoSmart P130
HP LaserJet 4240	HP OfficeJet 5110	HP PhotoSmart P230
HP LaserJet 4250	HP OfficeJet 5110xi	HP PhotoSmart P1000
HP LaserJet 4300	HP OfficeJet 6105	HP PhotoSmart P1100
HP LaserJet 4345 mfp	HP OfficeJet 6110	HP PhotoSmart P1115
HP LaserJet 4350	HP OfficeJet 7110	HP PhotoSmart P1215
HP LaserJet 5000	HP OfficeJet 7130	HP PhotoSmart P1218
HP LaserJet 5100	HP OfficeJet 7140	HP PhotoSmart P1315
HP LaserJet 5200	HP OfficeJet D125	HP e-printer e20
HP LaserJet 5200L	HP OfficeJet D135	IBM 4019
HP LaserJet 8000	HP OfficeJet D145	IBM 4029 030 LaserPrinter 10
HP LaserJet 8100	HP OfficeJet D155	IBM 4312
HP LaserJet 8150	HP OfficeJet G55	IBM Infoprint 12
HP LaserJet 9000	HP OfficeJet G85	IBM Page Printer 3112
HP LaserJet 9040	HP OfficeJet G95	Infotec 4353 MF
HP LaserJet 9040 MFP	HP OfficeJet K60	Infotec 4452 MF
HP LaserJet 9050	HP OfficeJet K60xi	Infotec 4651 MF
HP LaserJet 9050 MFP	HP OfficeJet K80	Infotec IS2022
HP LaserJet M3027 MFP	HP OfficeJet K80xi	Infotec IS2027
HP LaserJet M3035 MFP	HP OfficeJet LX	Infotec IS2032
HP LaserJet M4345 MFP	HP OfficeJet Pro 1150C	Infotec IS2035
HP LaserJet M5025 MFP	HP OfficeJet Pro 1170C	Infotec IS2045
HP LaserJet M5035 MFP	HP OfficeJet Pro 1175C	Infotec IS2090
HP LaserJet P2010	HP OfficeJet R40	Infotec IS2105
HP LaserJet P2015	HP OfficeJet R45	Infotec IS 2015
HP LaserJet P3004	HP OfficeJet R60	Infotec IS 2018
HP LaserJet P3005	HP OfficeJet R65	Infotec IS 2018D
HP Mopier 240	HP OfficeJet R80	Infotec IS 2060
HP Mopier 320	HP OfficeJet T45	Infotec IS 2075
HP OfficeJet 300	HP OfficeJet T65	Infotec IS 2122
HP OfficeJet 330	HP OfficeJet V40	Infotec IS 2127
HP OfficeJet 350	HP OfficeJet V40xi	Infotec IS 2132
HP OfficeJet 500	HP OfficeJetHP PSC 370	Infotec IS 2135

Infotec IS 2145	Kyocera FS-1030D	Kyocera FS-9500DN
Infotec IS 2151	Kyocera FS-1050	Kyocera FS-9530DN
Infotec IS 2160	Kyocera FS-1118MFP	Kyocera KM-1510
Infotec IS 2175	Kyocera FS-1135MFP	Kyocera KM-1530
Infotec IS 2215	Kyocera FS-1200	Kyocera KM-1810
Infotec IS 2216	Kyocera FS-1600	Kyocera KM-1815
Infotec IS 2220	Kyocera FS-1600+	Kyocera KM-1820
Infotec IS 2220D	Kyocera FS-1700	Kyocera KM-2030
Infotec IS 2225	Kyocera FS-1700+	Kyocera KM-2530
Infotec IS 2230	Kyocera FS-1714M	Kyocera KM-3050
Infotec IS 2235	Kyocera FS-1750	Kyocera KM-3530
Infotec IS 2245	Kyocera FS-1800	Kyocera KM-4050
Infotec IS 2255	Kyocera FS-1800+	Kyocera KM-4230
Infotec IS 2265	Kyocera FS-1900	Kyocera KM-4230/5230
Infotec IS 2275	Kyocera FS-1920	Kyocera KM-4530
Infotec IS 2316	Kyocera FS-2000D	Kyocera KM-5050
Infotec IS 2320	Kyocera FS-3500	Kyocera KM-5230
Infotec IS 2325	Kyocera FS-3600	Kyocera KM-5530
Infotec IS 2416	Kyocera FS-3600+	Kyocera KM-6030
Infotec IS 2425	Kyocera FS-3700	Kyocera KM-6230
Infotec IS 2430	Kyocera FS-3700+	Kyocera KM-8030
Infotec IS 2435	Kyocera FS-3718M	Lanier 5622
Infotec IS 2445	Kyocera FS-3750	Lanier 5627
Infotec IS 3090	Kyocera FS-3800	Lanier 5632
Infotec IS 3110	Kyocera FS-3820N	Lanier 5635
Infotec IS 3135	Kyocera FS-3830N	Lanier 5645
Infotec MP 2550	Kyocera FS-3900DN	Lanier LD0105
Infotec MP 2550B	Kyocera FS-4000DN	Lanier LD015
Infotec MP 3350	Kyocera FS-5800C	Lanier LD035
Infotec MP 3350B	Kyocera FS-5900C	Lanier LD045
Infotec MP 4000	Kyocera FS-6020	Lanier LD060
Infotec MP 4000B	Kyocera FS-6026	Lanier LD075
Infotec MP 5000	Kyocera FS-6300	Lanier LD090
Infotec MP 5000B	Kyocera FS-6500	Lanier LD115
Kyocera CS-1815	Kyocera FS-6500+	Lanier LD116
Kyocera F-1010	Kyocera FS-6700	Lanier LD118
Kyocera FS-600 - KPDL-2	Kyocera FS-6750	Lanier LD118d
Kyocera FS-600	Kyocera FS-6900	Lanier LD120
Kyocera FS-680	Kyocera FS-6950DN	Lanier LD120d
Kyocera FS-800	Kyocera FS-7000	Lanier LD122
Kyocera FS-920	Kyocera FS-7000+	Lanier LD127
Kyocera FS-1000	Kyocera FS-7028M	Lanier LD132
Kyocera FS-1000+	Kyocera FS-8000C	Lanier LD135
Kyocera FS-1010	Kyocera FS-9000	Lanier LD145
Kyocera FS-1018MFP	Kyocera FS-9100DN	Lanier LD151
Kyocera FS-1020D	Kyocera FS-9130DN	Lanier LD160

Lanier LD175	NRG 10515/10518/10512	NRG MP 5000
Lanier LD225	NRG 2205/2238/2212	NRG MP 5000B
Lanier LD230	NRG 2705/2738/2712	NRG MP 5500
Lanier LD235	NRG 3205/3238/3212	NRG MP 6500
Lanier LD245	NRG 3525/3508/3502	NRG MP 7500
Lanier MP2500/LD125	NRG 3545/3518/3532	NRG MP 9000
Lanier MP 1100/LD1100	NRG 4525/4508/4502	Oki B401d
Lanier MP 1350/LD1135	NRG 4545/4518/4532	Oki B430
Lanier MP 1600/LD316	NRG 6002/6005/6008	Oki B4350
Lanier MP 161/LD016	NRG 7502/7505/7508	Oki OL400
Lanier MP 2000/LD320d	NRG 9005/9008/9002	Oki OL400e
Lanier MP 2510/LD325	NRG DSm415	Oki OL400ex
Lanier MP 2550B/LD425B	NRG DSm615	Oki OL410e
Lanier MP 2550/LD425	NRG DSm616	Oki OL600e
Lanier MP 3010/LD330	NRG DSm618	Oki OL610e/S
Lanier MP 3350B/LD433B	NRG DSm618d	Oki OL800
Lanier MP 3350/LD433	NRG DSm620	Oki OL810ex
Lanier MP 3500/LD335	NRG DSm620d	Oki Okipage 6e
Lanier MP 4000B/LD040B	NRG DSm622	Oki Okipage 6ex
Lanier MP 4000/LD040	NRG DSm627	Oki Okipage 8p
Lanier MP 4500/LD345	NRG DSm632	Oki Okipage 10e
Lanier MP 5000B/LD050B	NRG DSm635	Oki Okipage 10ex
Lanier MP 5000/LD050	NRG DSm645	Oki Okipage 14ex
Lanier MP 5500/LD255	NRG DSm651	Oki Super 6e
Lanier MP 6500/LD265	NRG DSm660	Olivetti JP350S
Lanier MP 7500/LD275	NRG DSm675	Olivetti PG 306PCPI 1030
Lanier MP 9000/LD190	NRG DSm725	Panasonic KX-P4410
Lexmark 4076	NRG DSm730	Panasonic KX-P4450
Lexmark Optra E	NRG DSm735	Panasonic KX-P6150
Lexmark Optra E+	NRG DSm745	Panasonic KX-P6500
Lexmark Optra E220	NRG MP 1100	Raven LP-410
Lexmark Optra E321	NRG MP 1350	Ricoh Aficio 1022
Lexmark Optra E323	NRG MP 1600	Ricoh Aficio 1027
Lexmark Valuewriter 300	NRG MP 161	Ricoh Aficio 1032
Minolta PagePro 6	NRG MP 2000	Ricoh Aficio 1035
Minolta PagePro 6e	NRG MP 2500	Ricoh Aficio 1045
Minolta PagePro 6ex	NRG MP 2510	Ricoh Aficio 1060
Minolta PagePro 8	NRG MP 2550	Ricoh Aficio 1075
Minolta PagePro 8L	NRG MP 2550B	Ricoh Aficio 1515
Minolta PagePro 1100	NRG MP 3010	Ricoh Aficio 2015
NEC SuperScript 660i	NRG MP 3350	Ricoh Aficio 2016
NEC SuperScript 860	NRG MP 3350B	Ricoh Aficio 2018
NEC SuperScript 870	NRG MP 3500	Ricoh Aficio 2018D
NEC SuperScript 1260	NRG MP 4000	Ricoh Aficio 2020
NEC SuperScript 1400	NRG MP 4000B	Ricoh Aficio 2020D
NEC SuperScript 1800	NRG MP 4500	Ricoh Aficio 2022

Ricoh Aficio 2027	Samsung ML-1750	Savin 8016
Ricoh Aficio 2032	Samsung ML-2150	Savin 8020
Ricoh Aficio 2035	Samsung ML-2150PS	Savin 8020d
Ricoh Aficio 2035e	Samsung ML-2151N	Savin 8025
Ricoh Aficio 2045	Samsung ML-2151NPS	Savin 8025e
Ricoh Aficio 2045e	Samsung ML-2152W	Savin 8030
Ricoh Aficio 2051	Samsung ML-2152WPS	Savin 8030e
Ricoh Aficio 2060	Samsung ML-2250	Savin 8035/8035g
Ricoh Aficio 2075	Samsung ML-2550	Savin 8035e
Ricoh Aficio 2090	Samsung ML-2551N	Savin 8045/8045g
Ricoh Aficio 2105	Samsung ML-2552W	Savin 8045e
Ricoh Aficio 220	Samsung ML-4600	Savin 8055
Ricoh Aficio 3025	Samsung ML-5000a	Savin 8065
Ricoh Aficio 3030	Samsung ML-6000	Savin 8075
Ricoh Aficio 3035	Samsung ML-6100	Savin 8090
Ricoh Aficio 3045	Samsung ML-7000	Savin 8110
Ricoh Aficio 401	Samsung ML-7000N	Savin 8135
Ricoh Aficio 700	Samsung ML-7000P	Savin 816
Ricoh Aficio MP 1100	Samsung ML-7050	Savin 9016
Ricoh Aficio MP 1350	Samsung ML-7300	Savin 9021d
Ricoh Aficio MP 1600	Samsung ML-7300N	Savin 9025
Ricoh Aficio MP 161	Samsung QL-5100A	Savin 9025b
Ricoh Aficio MP 2000	Samsung QL-6050	Savin 9033
Ricoh Aficio MP 2500	Savin 2522	Savin 9033b
Ricoh Aficio MP 2510	Savin 2527	Savin 9040
Ricoh Aficio MP 2550	Savin 2532	Savin 9040b
Ricoh Aficio MP 2550B	Savin 2535/2235	Savin 9050
Ricoh Aficio MP 3010	Savin 2545/2245	Savin 9050b
Ricoh Aficio MP 3350	Savin 2560	Seiko SpeedJET 200
Ricoh Aficio MP 3350B	Savin 2575	Sharp AR-161
Ricoh Aficio MP 3500	Savin 3515	Sharp AR-M257
Ricoh Aficio MP 4000	Savin 40105	Sony IJP-V100
Ricoh Aficio MP 4000B	Savin 4015	Star LS-04
Ricoh Aficio MP 4500	Savin 4018	Star LaserPrinter 8
Ricoh Aficio MP 5000	Savin 4018d	Tally MT908
Ricoh Aficio MP 5000B	Savin 4022	Tektronix Phaser 750DP
Ricoh Aficio MP 5500	Savin 4027	Tektronix Phaser 750DX
Ricoh Aficio MP 6500	Savin 4035/4135g	Tektronix Phaser 750N
Ricoh Aficio MP 7500	Savin 4035e/4135eG	Tektronix Phaser 750P
Ricoh Aficio MP 9000	Savin 4045/4145g	Xerox Able 1406
Samsung ML-85	Savin 4045e/4145eG	Xerox DocuPrint 4508
Samsung ML-1250	Savin 4051	Xerox DocuPrint C20
Samsung ML-1450	Savin 4060	Xerox DocuPrint N4512
Samsung ML-1450PS	Savin 4075	Xerox DocuPrint N4512PS
Samsung ML-1650	Savin 4090	Xerox DocuPrint P12
Samsung ML-1651N	Savin 7025	Xerox DocuPrint P1202

Xerox DocuPrint P8e	Xerox Phaser 7400DX	Olympus P-11
Xerox Document Centre 400	Xerox Phaser 7400DXF	Olympus P-200
Xerox Phaser 2135	Xerox Phaser 7400N	Olympus P-300
Xerox Phaser 4400B	Xerox Phaser 7700DN	Olympus P-300E
Xerox Phaser 4400DT	Xerox Phaser 7700DX	Olympus P-300U
Xerox Phaser 4400DX	Xerox Phaser 7700GX	Olympus P-330E
Xerox Phaser 4400N	Xerox Phaser 7750B	Olympus P-330NE
Xerox Phaser 4500B	Xerox Phaser 7750DN	Olympus P-400
Xerox Phaser 4500DT	Xerox Phaser 7750DXF	Olympus P-440
Xerox Phaser 4500DX	Xerox Phaser 7750GX	Olympus P-S100
Xerox Phaser 4500N	Xerox Phaser 7760DN	Canon CP-10
Xerox Phaser 4510B	Xerox Phaser 7760DX	Canon CP-100
Xerox Phaser 4510DT	Xerox Phaser 7760GX	Canon CP-200
Xerox Phaser 4510DX	Xerox Phaser 8400B	Canon CP-220
Xerox Phaser 4510N	Xerox Phaser 8400BD	Canon CP-300
Xerox Phaser 5500B	Xerox Phaser 8400DP	Canon CP-330
Xerox Phaser 5500DN	Xerox Phaser 8400DX	Canon SELPHY CP400
Xerox Phaser 5500DT	Xerox Phaser 8400N	Canon SELPHY CP500
Xerox Phaser 5500DX	Xerox Phaser 8500DN	Canon SELPHY CP510
Xerox Phaser 5500N	Xerox Phaser 8500N	Canon SELPHY CP520
Xerox Phaser 6130N	Xerox Phaser 8550DP	Canon SELPHY CP530
Xerox Phaser 6180DN	Xerox Phaser 8550DT	Canon SELPHY CP600
Xerox Phaser 6180MFP-D	Xerox Phaser 8550DX	Canon SELPHY CP710
Xerox Phaser 6200B	Xerox Phaser 8560DN	Canon SELPHY CP720
Xerox Phaser 6200DP	Xerox WorkCentre 7345	Canon SELPHY CP730
Xerox Phaser 6200DX	Xerox WorkCentre M118	Canon SELPHY CP740
Xerox Phaser 6200N	Datamax-ONeil I4212e Mark II	Canon SELPHY CP750
Xerox Phaser 6250B	Datamax-ONeil I4310e Mark II	Canon SELPHY CP760
Xerox Phaser 6250DP	Datamax-ONeil I4606e Mark II	Canon SELPHY CP770
Xerox Phaser 6250DT	Datamax-ONeil E4204B Mark III	Canon SELPHY CP780
Xerox Phaser 6250DX	Datamax-ONeil E4304B Mark III	Canon SELPHY CP790
Xerox Phaser 6250N	Datamax-ONeil E4205A Mark III	Canon SELPHY CP800
Xerox Phaser 6300DN	Datamax-ONeil E4305A Mark III	Canon SELPHY CP810
Xerox Phaser 6300N	Datamax-ONeil E4206P Mark III	Canon SELPHY CP820
Xerox Phaser 6350DP	Datamax-ONeil E4305P Mark III	Canon SELPHY CP900
Xerox Phaser 6350DT	Datamax-ONeil E4206L Mark III	Canon SELPHY CP910
Xerox Phaser 6350DX	Datamax-ONeil E4305L Mark III	Canon SELPHY CP1000
Xerox Phaser 6360DN	Datamax-ONeil RL3e	Canon SELPHY CP1200
Xerox Phaser 6360DX	Datamax-ONeil RL4e	Canon SELPHY ES1
Xerox Phaser 7300B	Compaq IJ1200	Canon SELPHY ES2
Xerox Phaser 7300DN	Lexmark X73	Canon SELPHY ES3
Xerox Phaser 7300DT	Lexmark Z42	Canon SELPHY ES20
Xerox Phaser 7300DX	Lexmark Z43	Canon SELPHY ES30
Xerox Phaser 7300N	Lexmark Z52	Canon SELPHY ES40
Xerox Phaser 7400DN	Lexmark Z53	Sony UP-DP10
Xerox Phaser 7400DT	Olympus P-10	Sony UP-DR150

Sony DPP-EX5	Kodak 605	Shinko CHC-S6145
Sony DPP-EX7	Kodak 1400	Sinfonia CHC-S6145/CS2
Sony UP-DR100	Kodak 805	CIAAT Brava 21
Sony UP-DR200	Mitsubishi CP-9550D	Dai Nippon Printing DS40
Sony UP-CR10L	Mitsubishi CP-9550DW	Dai Nippon Printing DS80
Dai Nippon Printing SL10	Mitsubishi CP-D70DW	Dai Nippon Printing DSRX1
Fujifilm Printpix-CX-400	Mitsubishi CP-K60DW-S	Dai Nippon Printing DS620
Fujifilm Printpix-CX-550	Mitsubishi CP-D80DW	Citizen CX
Fujifilm FinePix-NX-500	Kodak 305	Citizen CX-W
Kodak Easyshare-Printer-Dock	Mitsubishi CP-9600DW	Citizen CY
Kodak EasyShare-G600-Printer-Dock	Mitsubishi CP-9550DZ	Citizen CW-01
Kodak PD-4000	Mitsubishi CP-9550DW-S	Citizen OP900
Kodak PD-6000	Mitsubishi CP-9800DZ	Mitsubishi CP-3800DW
Kodak Photo-Printer	Mitsubishi CP-9800DW-S	Dai Nippon Printing DS820
Kodak Photo-Printer-500	Mitsubishi P95D	
Kodak Printer-Dock-Plus	Shinko CHC-S9045	
Kodak Printer-Dock-Plus-S3	Mitsubishi CP-9500DW	
Kodak 6800	Shinko CHC-S2145	
Kodak 6850	Sinfonia S2145/S2	