

ICP Techniques & Applications



Inductively Coupled Plasma

TO WHOM WE PRESENTS

1- Beginners in iCAP .

- To known a new technique
- Help them to buy the instrument.
- To spread the acknowledgement.

2- Intermediates in iCAP.

- To rearrange their ideas about iCAP
- To concentrate on the component of instrument.
- To restart with a new ideas.

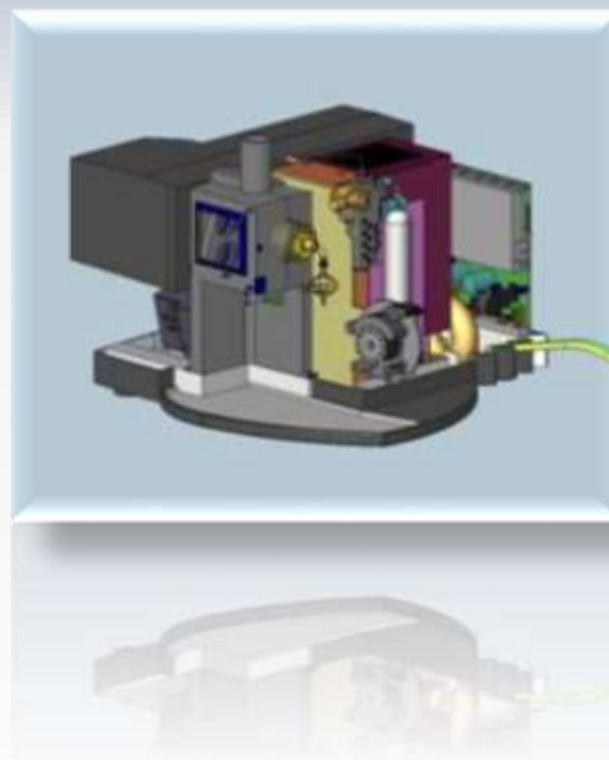
3- Experts in iCAP.

- To see some different presentation



Contents

- Introduction
- Basic theory of operation
- The functional parts of ICP
- Analysis
- Interferences
- Accessories
- Maintenance
- Applications



INTRODUCTION



ICP-AES

Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES)

- It is a multi-element analysis technique that will dissociate a sample into its constituent atoms and ions and exciting them to a higher energy level.
- Cause them to emit light at a characteristic wavelength , which will be analysing

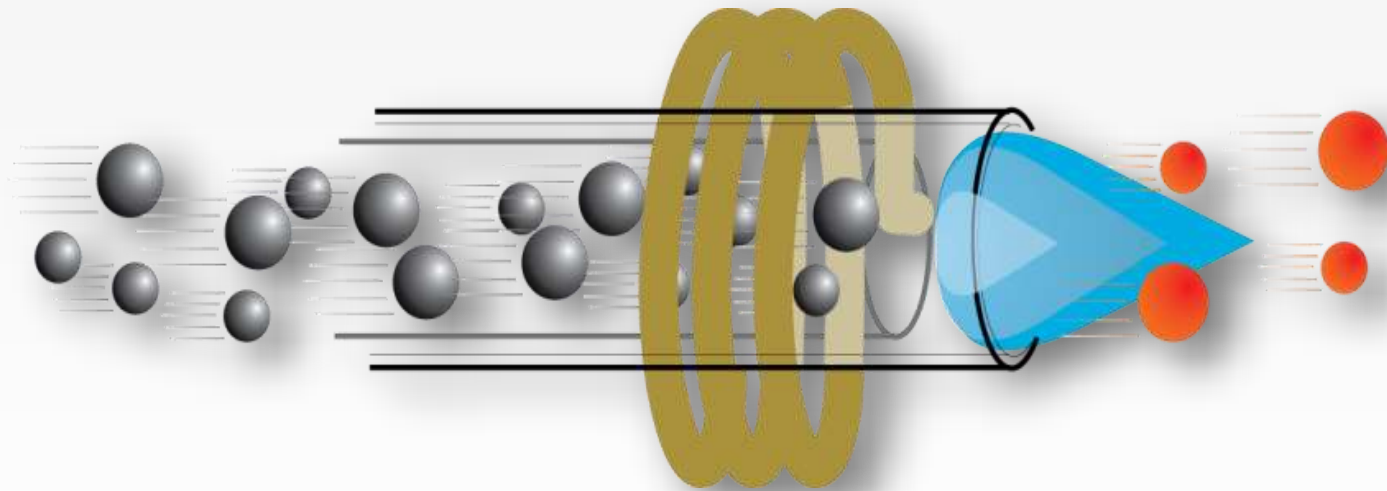
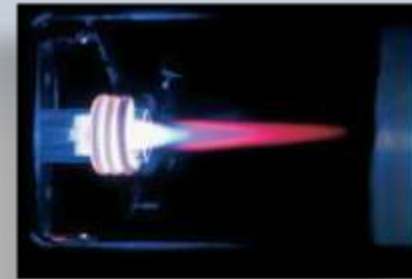


Sequence

1. The sample is nebulized and entrained in the flow of plasma support gas, which is typically Ar.
2. The plasma torch consists of concentric quartz tubes.
3. The inner tube contains the sample aerosol and Ar support gas and the outer tube contains flowing gas to keep the tubes cool.
4. A Radiofrequency (RF) generator produces an oscillating current in an induction coil that wraps around the tubes.
5. The induction coil creates an oscillating magnetic field, which produces an oscillating magnetic field, The magnetic field in turn sets up an oscillating current in the ions and electrons of the support gas (argon).
6. As the ions and electrons collide with other atoms in the support gas

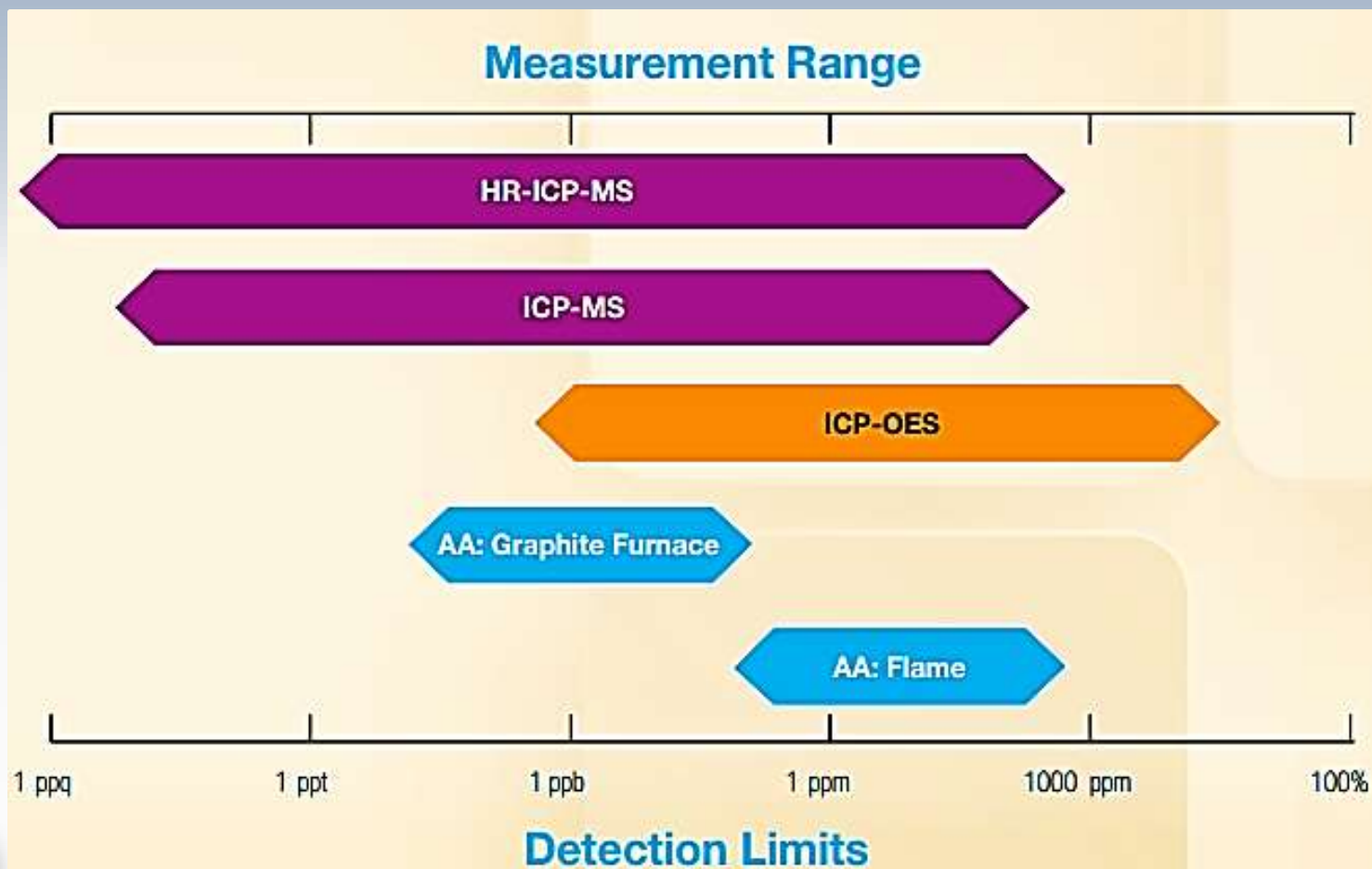
Plasma

Gas in which a significant number of atoms are ionized (significant being $>1\%$) Will interact with a magnetic field Inductive coupling between varying field and the plasma .



Inductively Coupled Plasma

Detection limits



Detection Limits

1 ppq

1 ppt

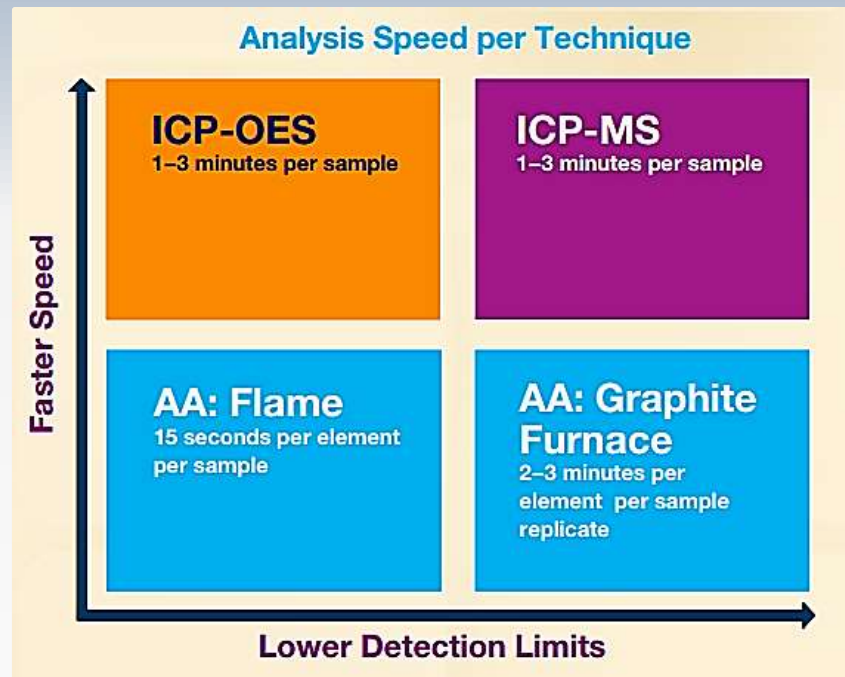
1 ppb

1000 ppm

100%

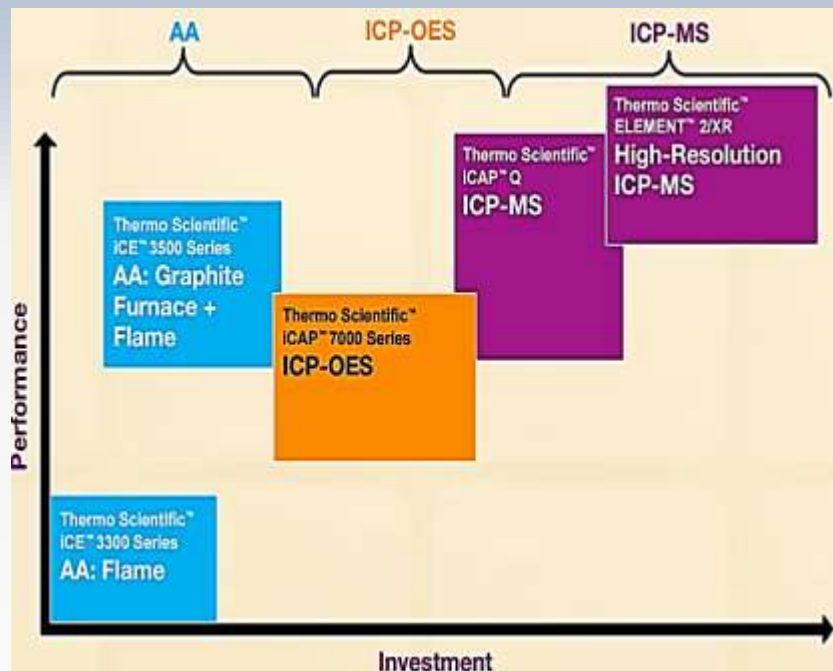
ANALYSIS SPEED

- Consider the analysis time for each technique, and the number of samples you will need to test in a day.
- Which technique will fit into your production timelines?
Does the same technique also support the detection limits you require?



THE ECONOMICS OF OWNERSHIP

- The instrumentation you select must also work within your lab's budget. Not just your budget for the initial purchase, but also for maintenance, consumables, training, and service.
- When you consider overall instrument performance (detection limits, linearity, target analytes) as well as your timelines and budget, which technique is right for your lab?

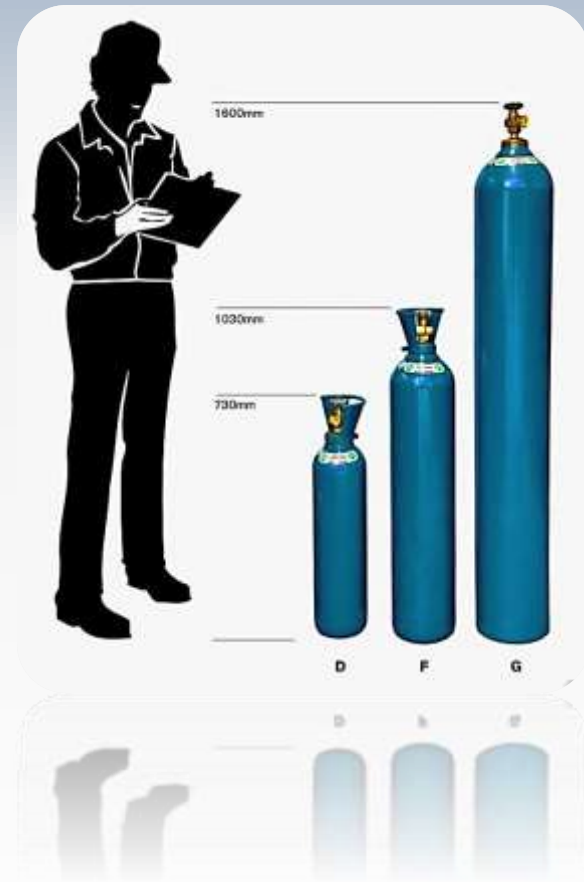


ARGON CONSUMPTION (LIQUID)

No.	No. Of Hours	Purge Rate	Flow Rate	Total
1	10	2	10	12
2	30	7	30	37
3	50	11	50	61
4	70	15	70	85
5	91	19	90	109
6	111	24	110	134
7	131	28	130	158
8	151	32	150	182
Liters of liquid argon				

ARGON CONSUMPTION (GAS)

- A G size mixed argon gas cylinder contains 8.7 cubic meters of gas (8700 Liters).
- The cylinder dimensions are 163cm high x 27cm diameter.
- Average rate of 20 L / min.
- The cylinder will be enough for more than 7 hours.
- More than 200 samples will analyzed using one cylinder.
- Note: (1 L liquid = 781 L gas) Argon



Important criteria

Selecting a technique requires the consideration of a variety of important criteria, including:

- Detection limits
- Analytical working range
- Sample throughput
- Data quality
- Cost
- Interferences
- Ease-of-use
- Availability of proven methodology



BASIC THEORY



Inductively Coupled Plasma

Chemistry is the science of study the interaction between energy and matter

1 H																	2 He														
3 Li	4 Be																	5 B	6 C	7 N	8 O	9 F	10 Ne								
11 Na	12 Mg																	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar								
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr														
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe														
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun								

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

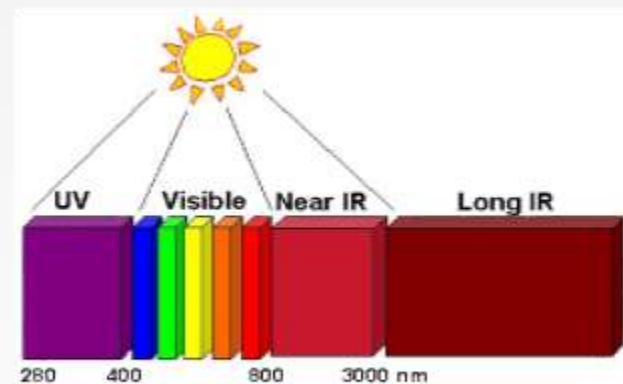
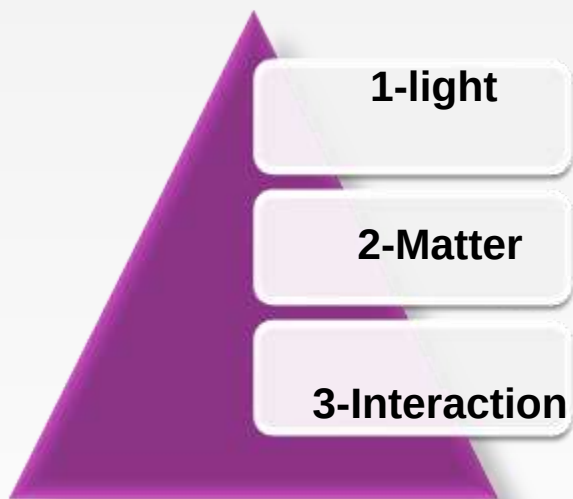
1-Energy

2-Matter

3-Interaction

Spectroscopy

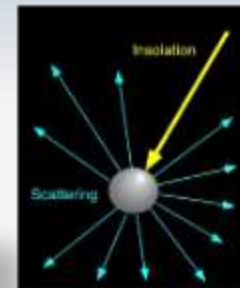
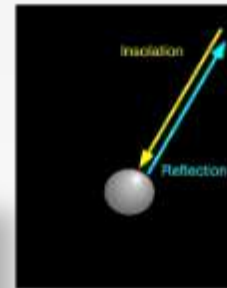
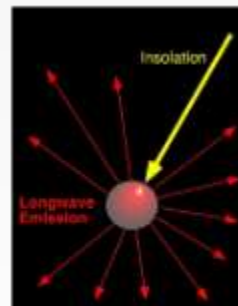
spectroscopy is the science of study the
interaction between light and matter



Light

Types of interactions

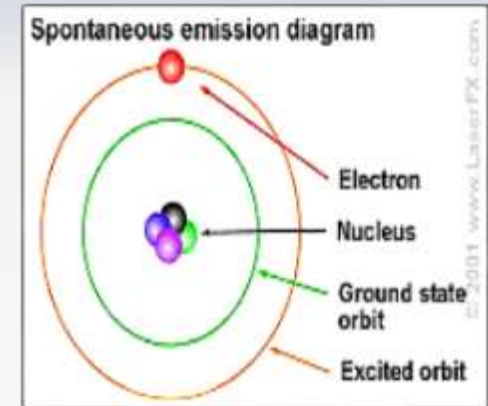
- Absorption
- Emission
- Scattering
- Refraction
- Reflection



Emission

Steps

1. Electrons in the element are excited.
2. They jump to higher energy levels (excited state).
3. As the electrons fall back down (ground state).
4. Emitted(photon), the wavelength of which refers to the discrete lines of the emission spectrum.



The emission spectrum can be used to determine the composition of a material

ICP

Steps

1. Plasma will dissociate a sample into atoms , ions.
2. Exciting them to a higher energy level.
3. They emit light at a characteristic wavelength .
4. The emitted light, will be analysing .



The instrument will know the concentration of metals inside the sample, using standard solutions.

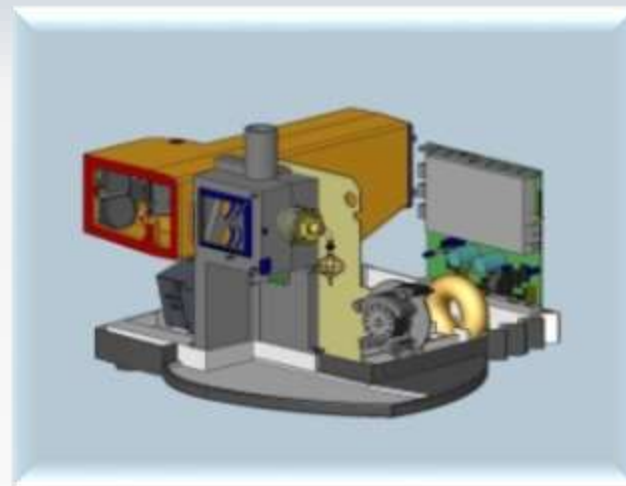
FUNDAMENTAL PARTS



The functional parts of ICP

The iCAP 6000 spectrometer consists of several major components:

1. Sample introduction parts. Plasma torch.
2. Gas control.
3. Radio frequency power generator.
4. Optical system; Polychromator.
5. CID detector with thermoelectric cooling.
6. Interlocks.



1. Sample introduction parts

- a. Pump.
- b. Nebulizer.
- c. Spray chamber.
- d. Centre tube.
- e. Torch.



a. Peristaltic pump

- 4-channel 12-roller pump, with its unique drain sensor.
- Sample introduction shall be via an integral, close coupled and variable speed,
- The pump speed shall be computer controlled to provide programmable sample flows both during and between sample measurements .
- Included for the pump to be automatically switched into a standby mode upon instrument shutdown.



b. Nebulizer

1. The sample solution after being sprayed by the nebulizer.
2. Entrained in argon as a fine mist.
3. Passes through the center channel of the torch and into the plasma.

Control of the nebuliser pressure, or flow, is either through the control software or via a manual adjustment.



Types of nebulizer

Nebulizer: Glass concentric fitted as standard; optional: Aerosalt (high solids concentric), V-groove, Miramist (HF resistant), Ultrasonic nebulizer.

AeroSalt Nebuliser

- Above 5% m/v dissolved solids in a sample will require the use of an AeroSalt Nebuliser.
- A high solids centre tube and argon humidifier should also be used.

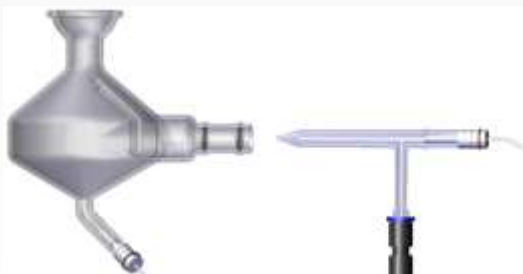
V-Groove Nebuliser

- Above 15% m/v dissolved solids in a sample will require the use of a Vgroove nebuliser.
- A high solids centre tube and argon humidifier should also be used.

c. Spray chamber

Cyclone spray chamber

- Most samples are liquids that are pumped through a nebulizer to produce a fine spray.
- The large droplets are removed by a spray chamber and the small droplets then pass through to the plasma.



Organic solvent chamber

1. The organic solvent leads to more sample and matrix loading of the plasma.
2. This may impair the analysis, or even extinguish the plasma.
3. The organic sample spray chamber has a baffle tube inside.
4. This will reduce the sample aerosol density;
5. Flow rates must be carefully controlled by adjusting the pump speed.



HF sample chamber

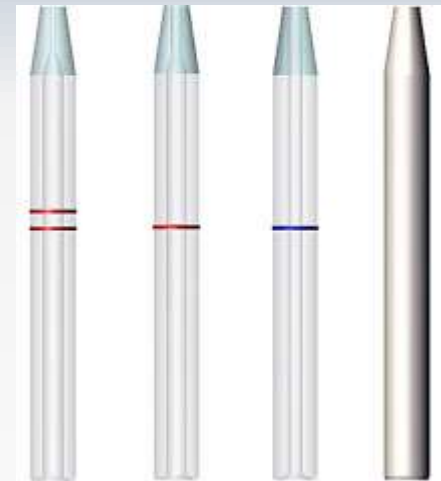
- Hydrofluoric (HF) has to be used to dissolve a sample.
- HF will react and dissolve the standard sample introduction glassware.
- Most of the glassware will have to be replaced with Optional HF resistant components.
- The components that must be exchanged are:
 1. Ceramic centre tube.
 2. HF resistant nebuliser.
 3. HF resistant spray chamber, with adaptor.



d. Centre tube

Types of Centre tube

- 1) 1.5mm quartz for aqueous solutions (single red ring)
- 2) 1.0mm quartz for organic solutions (double red ring)
- 3) 2.0mm quartz for high dissolved solids solutions (single blue ring, standard on Duo configurations)
- 4) 2.0mm Ceramic for HF solutions



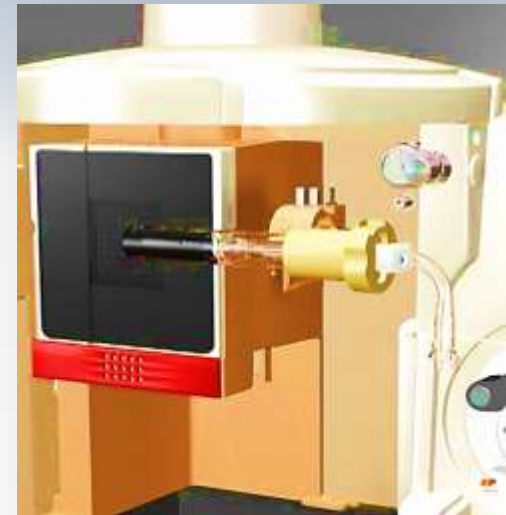
e. Plasma torch

- The quartz torch surrounded by the copper induction coil.
- The copper coil is made from copper tubing and is kept cool by circulating water.
- RF energy is supplied to the coil which inductively heats the argon gas to approximately 10,000°C.
- At this temperature the gas turns into a plasma of positively charged atoms and electrons.
- The plasma is kept off the sides of the quartz torch by a separate flow of argon supplied tangentially to the inside torch.



e. Torch alignment

- The torch design shall include a quick release, Pre-aligned mounting block which minimizes torch alignment when reinstalling.
- Doesn't require tools for removal.
- The mount shall incorporate the plasma gas connections so that when the torch is inserted gases will be automatically connected.



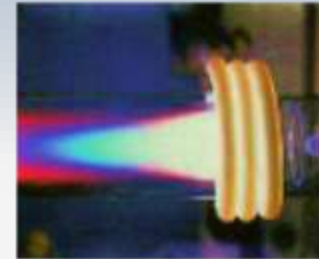
Radial torch

- Radial plasma looks through the side of the plasma and is best suited for high matrix tolerance and concentration
- Radial design for Robust, fewer interferences,
 - Petrochemical.
 - Metallurgy.



Axial torch

- Axial view plasma looks down the central channel of the plasma, this provides the best sensitivity and lowest detection limits
- Axial design
 - Environmental,
 - Chemical.

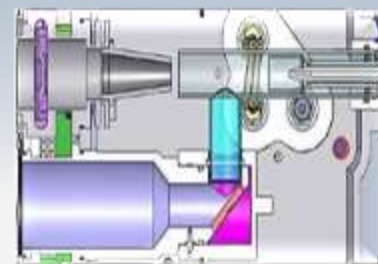


DUO torch

DUO – this is an axially configured plasma that also allows for radial view through a hole in the side of the axial torch

Plasma Viewing

- The plasma shall be viewed axially with a modified torch extended to screen off atmospheric gases . Auxiliary optics shall be available to provide a radial plasma view.
- The instrument shall have the possibility to automatically switch between axial and radial view during an analysis.



iCAP torch box

1. Common casting – radial and duo
2. Managed air flow .
3. Torch.
4. Coil .
5. Exhaust sensor,
6. Unique drain sensor
7. Quick-fit and demount interlocked torch



2. Gas control

iCAP 7200

- The nebulizer gas flow is manually controlled from 0 to 0.4 MPa.
- The auxiliary gas is controlled with precision restrictors with flows of 0, 0.5, 1.0 and 1.5 L/min. The coolant flow is fixed at 12 L/min.

iCAP 7400

- The nebulizer gas is computer controlled through an MFC with options from 0 - 1.5 L/min with increments of 0.1 L/min.
- The auxiliary gas is computer controlled through an MFC with options from 0 - 2 L/min in 0.1 L/min increments.
- The coolant flow is computer controlled through an MFC from 0 - 20 L/min.

Argon

Gas Control

- Operation of the gas system shall be under full computer control with mass flow controllers on all three plasma gases.
- Coolant flow shall operate over 0-20 L/Min in steps of 1 L/Min
- Auxiliary flow shall operate over 0-2 L/Min in steps of 0.1 L/Min, and.
- Nebulizer gas shall operate over 0-1.5 L/Min in steps of 0.01 L/Min.
- An optional mass flow controller shall be available for the addition of supplementary gases to the plasma.



PURGE GAS

- The entire spectrometer and fore optics are purged with either argon or nitrogen.
- A normal running flow of 2 L/min is used with a boost of 2 L/min for optimum performance at wavelengths <200 nm.
- A purged environment is maintained with a standby flow of 1 L/min when the plasma is extinguished.



Gas requirements

The spectrometer will require argon at

- 90psi (minimum quality of 99.995% pure with
- Less than 10ppm water
- Less than 10ppm oxygen
- Used for operation and optical path purge).
- The maximum flow requirement will be 20 l/min .
- Nitrogen can be used, instead of argon for optical path purge.

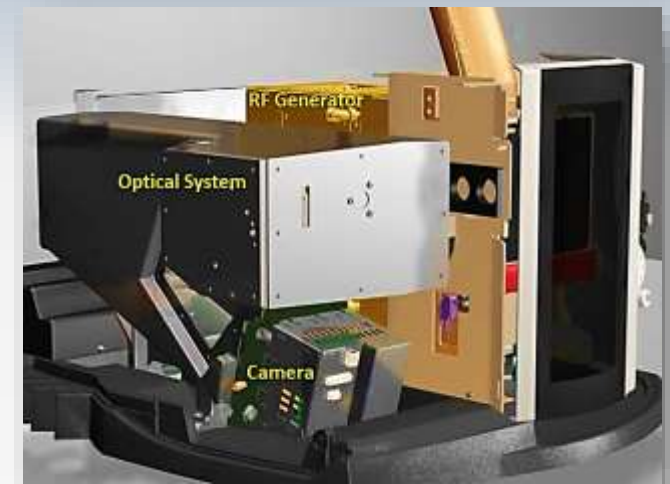


3. Radio frequency RF power generator

- Swing frequency impedance control
- Frequency changes to match plasma load
- Fast response, no complex matching networks
- >78% Efficiency Ability to run even difficult organics e.g. methanol
- Nominal Frequency: 27.12 MHz
- Full range of power control

750-1600w Radial, 750-1350w Duo

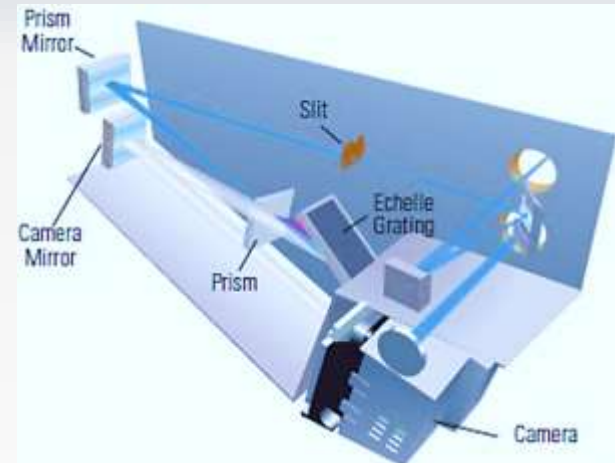
Optimum performance for all sample types.



4. Optical system

Wavelength Range.

- The instrument shall be able to operate over the range of 166.250 to 847.000 nm
- All elements must be represented by at least 3 sensitive and 3 secondary lines to satisfy the requirements of a wide range of sample types.
- An optical resolution of better than 0.007nm at 200nm, 0.014nm at 400nm and 0.021nm at 600nm.

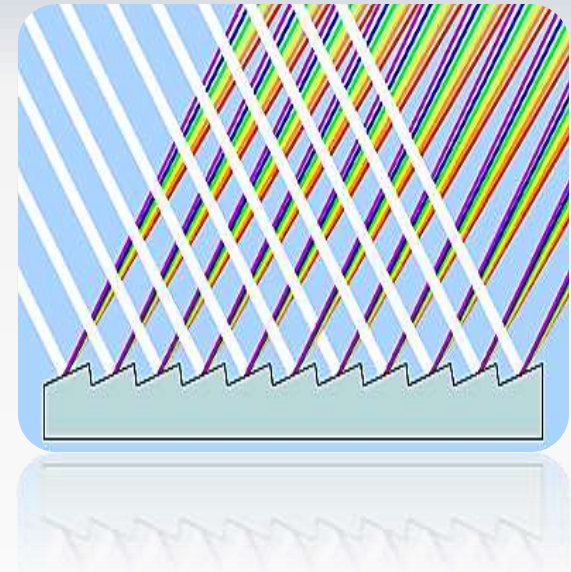


Optical layout

- The components of the resolving optics are contained in a sealed tank which is purged with argon.
- Light enters the optical tank via two entrance apertures.
- Depending on the wavelength range selected, for Low Wavelengths and for High Wavelengths).
- The light then passes through a shutter mechanism controlling the exposure time for each determination, then to a collimating mirror, a prism and reflects off the Echelle Grating.
- The light passing to the focussing mirror and finally through a silica window onto the CID detector.

Echelle grating

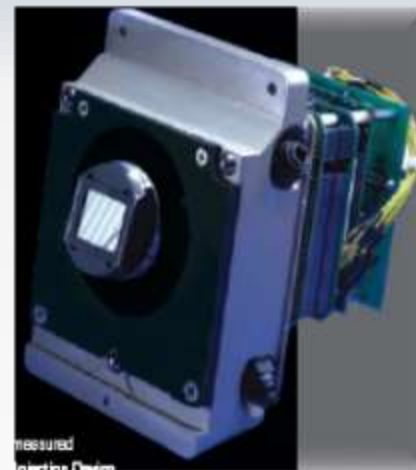
- **Grating** An optical device within the spectrometer used to separate the emitted light into its component wavelengths.
- The grating has a dual feature: it diffracts the light and focuses it on the slits.
- The grating is the main optic part of the spectrometer;
- It separates the light into all the wavelength that composes it.
- The Echelle grating has 52.91 lines/mm operating in high orders for high dispersion.



5. Charge injection device

CID DETECTOR

- New CID86 chip (Charge Injection Device)
- Allows free choice of wavelengths from 166 to 847 nm.
- More stable, lower noise
- With the ability to measure transient signals.
- Thermoelectric cooling by a triple stage peltier
- Reduce dark current and background noise resulting in enhanced detection limits.



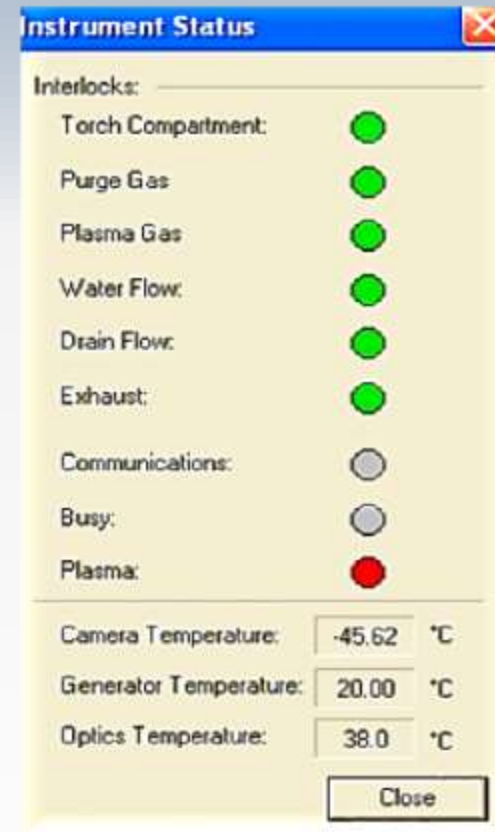
Detector operating modes

- The detector must be capable of operating in the following modes :-
 - Analysis .
 - Full Frame Imaging.
- The detector must be photoactive over the whole surface area for continuous wavelength coverage.
- It must contain a minimum of 540 x 540 pixels.
- Pixel Size: 27 x 27 μm
- The CID detector is kept at very low temperature (-45 C) in the instrument in order to minimise the noise.



6. Interlocks

- Torch compartment
- Purge gas
- Plasma gas
- Water flow
- Drain flow
- Exhaust
- Communication
- Busy
- Plasma



Recirculating cooling system

An air-cooled re-circulating water chiller shall be provided to cool

1. The load coil
2. RF generator
3. Detector components

suitable for operation with an ambient temperature range +15 C to + 35 C



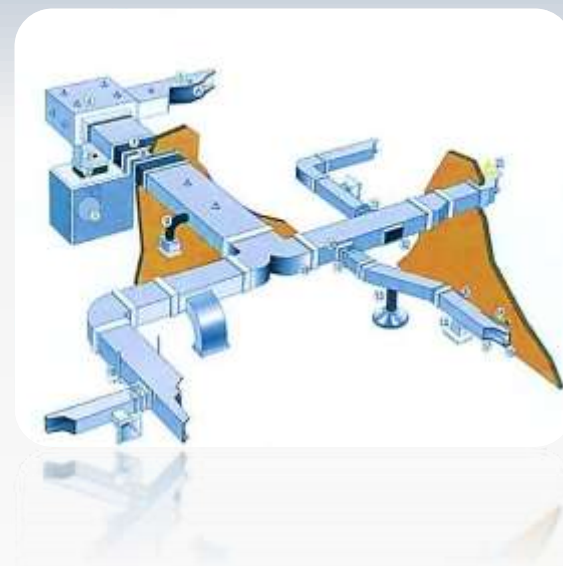
Argon extraction

- Argon is slightly heavier than air and tends to settle in the bottom of the torch compartment.
- An argon environment is ideal for supporting high voltage discharge.
- The vent is designed to “pull” the argon up and out of the torch compartment.
- The extraction must be capable of exceeding a velocity of 10m.s^{-1} (33 feet/sec) through the 125mm (5in) internal diameter, flexible, extraction tube supplied with the instrument.
- An iCAP6000 Duo instrument will require a minimum of 8.5m.s^{-1} and a Radial 4m.s^{-1} .



Fume extraction

- The laboratory must be free of all contaminants that could have a degrading effect on the instrument components.
- Dust, acid and organic vapours must be excluded from the work area.
- Warranty will be void if the equipment is operated in substandard conditions.
- **WARNING:** The spectrometer must never be operated without an effective fume extraction.



ANALYSIS

SAMPLE PREPARATION

Microwave digestion

- Short digestion times. Minutes, not hours
- No loss of volatile elements. Complete recovery of Hg, As, Cd etc.
- No acid fumes. Improved laboratory working conditions.
- No sample contamination from the environment.
- No cross contamination.
- Low blanks, as minimal quantities of acids are used.



STANDARDS PREPARATION

There are several ways in making multi-element working standard solutions:-

- By using standards from single-element primary standards, multi-element primary standards,
- And/or a combination of single-element and multi-element primary standards.
- It is a widely accepted practice to use NIST SRMs (standard reference materials) to validate various kinds of laboratory operations.



WATER & CHEMICALS

- Forget about grids.
- But, All types of acids, water and other used chemicals should be free of the required elements.



Analysis

Qualitative analysis and quantitative determines

- Qualitative analysis involves the determination of *“what”* is in your sample.
- Quantitative determines *“how much”* is in your sample.
- Almost every element will emit radiation in the UV and/or Vis region of the spectrum when excited in the plasma.
- So it is dependant on the analyst as to how to use the information gained from this qualitative analysis to aid in the development of a method for quantitative analysis



Qualitative analysis

What is Full frame ?

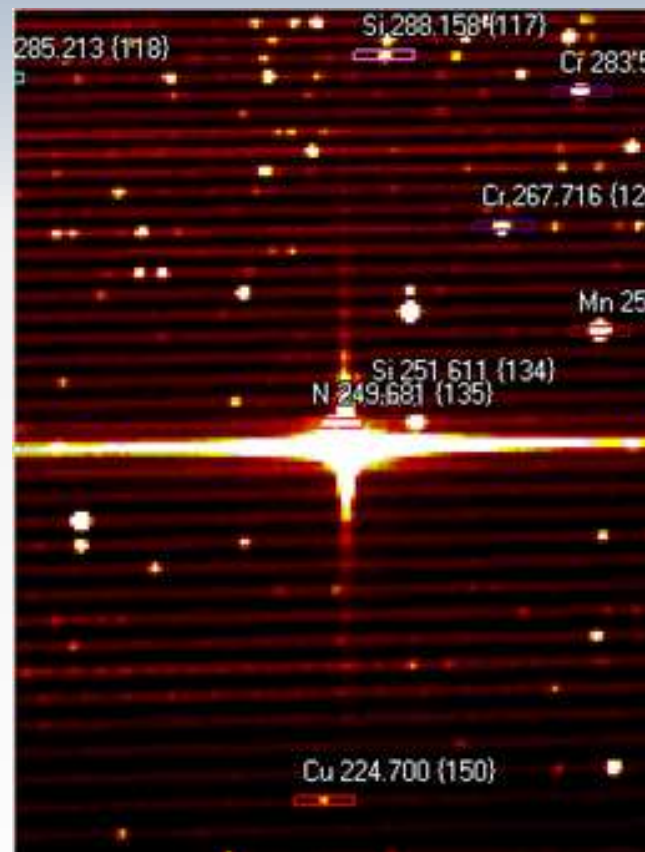
- A Fullframe is a graphical depiction of the CID chip.
- All wavelengths are displayed and can be identified and semi quantitatively analysed.
- A *Fullframe* image includes all lines that are emitted by the sample.
- The bright spots are elements in your sample....the brighter the spot, the higher the concentration!



Fullframe functions

- Identify all elements in a solution
- Semi quantitatively determine their concentration
- Fingerprint samples, batch and trend analysis
- Identify contaminants from one batch to the next by subtracting Fullframe from each other

All of these functions can be performed
“live” or post run!



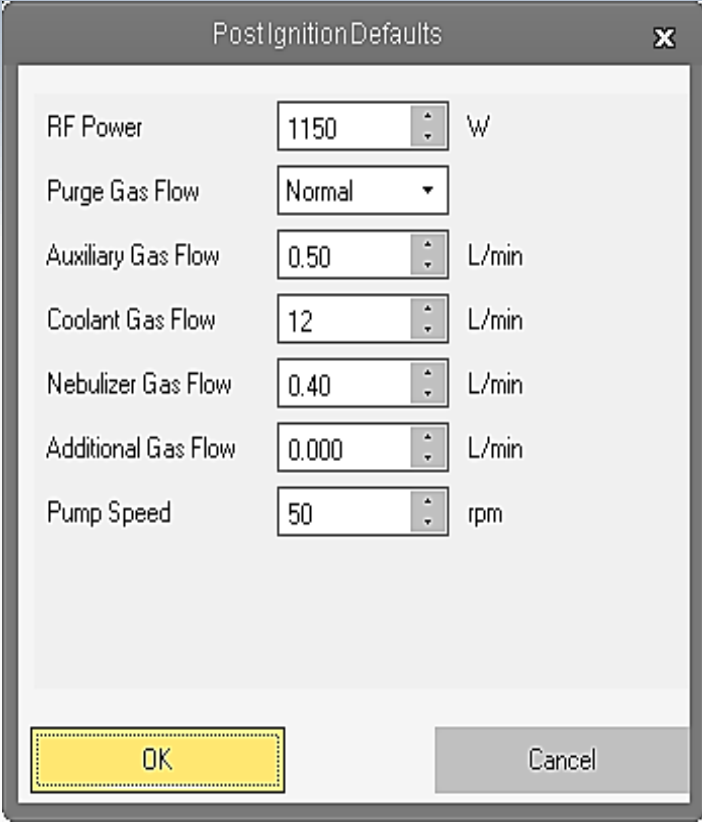
Quantitative analysis

- Optical emission spectrometry is a comparative technique in which the signals from solutions of known concentrations used to generate a calibration curve is compared to the signals of unknown samples to generate results



OPERATION PARAMETER

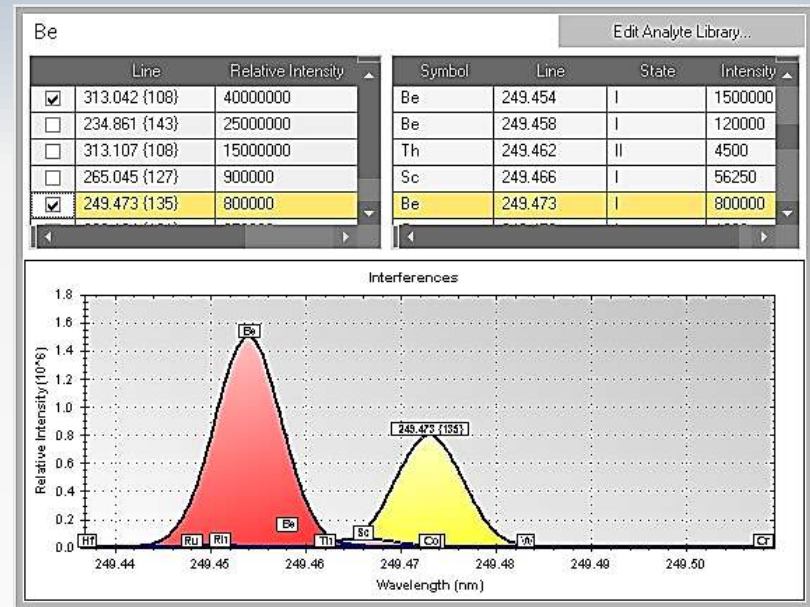
The conditions used for the operation of the ICP and the measurement of emission are important for any ICP methodology.

A screenshot of a software dialog box titled "Post Ignition Defaults" with a close button (X) in the top right corner. The dialog contains seven parameters, each with a label, a value field, and a unit. The parameters are: RF Power (1150 W), Purge Gas Flow (Normal), Auxiliary Gas Flow (0.50 L/min), Coolant Gas Flow (12 L/min), Nebulizer Gas Flow (0.40 L/min), Additional Gas Flow (0.000 L/min), and Pump Speed (50 rpm). The value fields are either spinners or dropdown menus. At the bottom, there are two buttons: "OK" (highlighted in yellow) and "Cancel".

Parameter	Value	Unit
RF Power	1150	W
Purge Gas Flow	Normal	
Auxiliary Gas Flow	0.50	L/min
Coolant Gas Flow	12	L/min
Nebulizer Gas Flow	0.40	L/min
Additional Gas Flow	0.000	L/min
Pump Speed	50	rpm

WAVELENGTH SELECTION

- A various lines that are emitted for Each element.
- The analyst can choose the optimum line for a given analysis.
- The actual line that is selected is dependent on a number of factors including the presence of the interfering elements ,and the desired sensitivity range .



RUN THE ANALYSIS



The software was described in another presentation

INTERFERENCES



Interferences

TYPES OF INTERFERENCES COMMON TO ICP-OES

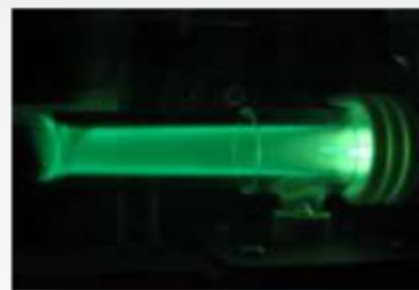
1. PHYSICAL
2. CHEMICAL
3. SPECTRAL



1. Physical interferences

A characteristic difference between sample and standard which affects sample introduction or nebulisation

1. Viscosity
2. High Dissolved Solids (density)
3. Acid type or concentration
4. Surface tension
5. Organic solvents



Physical interferences can be easily overcome by matrix matching of the standards, and/or use of an internal standard

Solving physical interferences

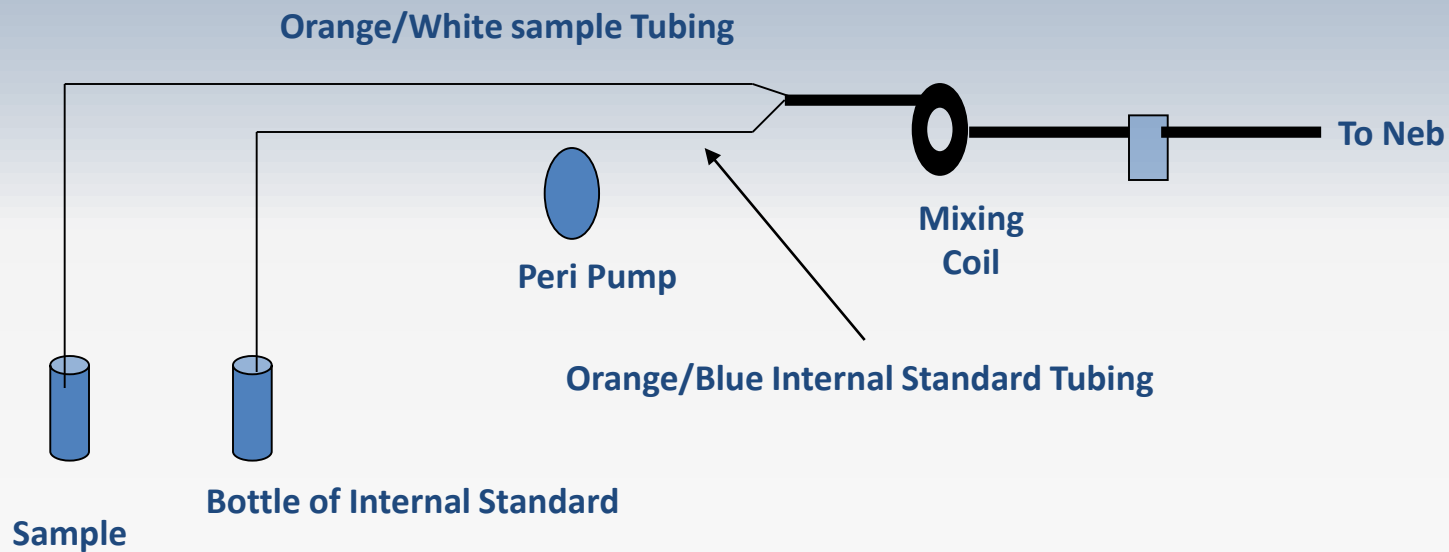
1. Dilution (degrades detection limits)
2. Matrix matching (must be known to be effective)
3. Internal Standardisation
4. Method of Standard Additions



Use of internal standards

- Internal standards are dynamic drift corrections used to correct for physical differences in samples and standards by referencing all samples to the same element performance
- A correction is then applied to the sample in accordance with the suppression or enhancement of signal experienced by the Internal standard Element
- Internal Standards must be referenced to elements that will react the same way in the plasma, i.e. they are all UV, or all ionic lines
- An element wavelength and its IS wavelength should have the same plasma view Axial / Axial, and Radial / Radial

Internal standards mixing kit



Internal Standard is mixed at a 1 to 5 ratio with Sample

2. Chemical interferences

A sample matrix characteristic which causes an analyte to behave differently in the sample and standard

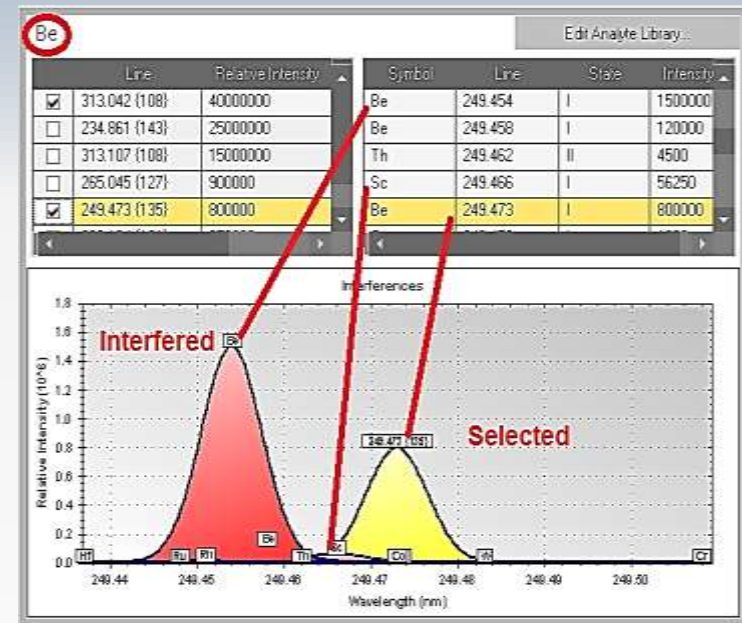
1. Ionisation (Na, K, Rb, Cs, Li)
2. Molecular formation (i.e. oxides)
3. Plasma Loading

Chemical interfaces can be over come by use of an ionisation buffers, internal standards, matrix matching of the samples and standards.

3. Spectral interferences

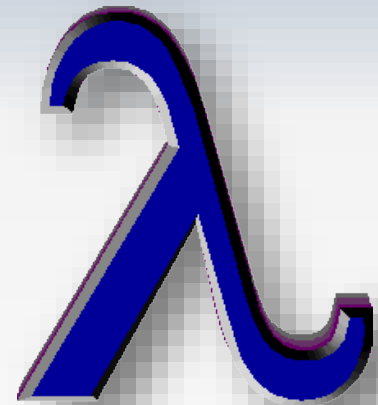
1. Severe in ICP-OES
2. Need to use off-peak background correction
3. Interfering Element Correction (IEC)

Spectral Interferences can be easily overcome by wavelength selection and optimisation of the sub-arrays



Wavelength selection

- When a samples constituent elements are excited in the plasma, almost all elements present will emit a series of characteristic lines as their excited states return to the ground state.
- A various lines that are emitted for Each element.
- The analyst can choose the optimum line for a given analysis.
- The actual line that is selected is dependent on a number of factors including the presence of the interfering elements ,and the desired sensitivity range .



Sub-array

- During analysis, the CID detector is read in a sub-array configuration.
- In order to reduce the read cycle time, all analytical wavelengths are designated, as a small array that, by default for UV is 5 pixels tall by 12 pixels wide and for the VIS is 2 pixels high by 12 pixels wide.
- The maximum size for any Subarray is 24 pixels wide by 7 high.

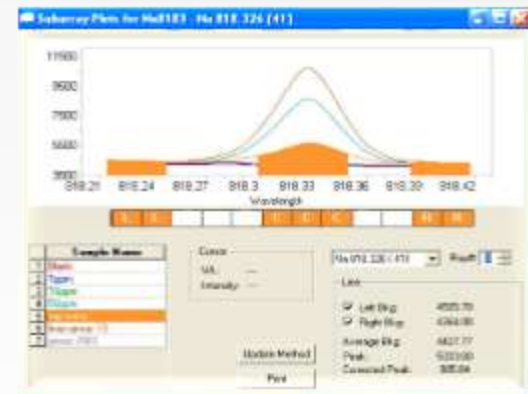


Sub-array functions

Figure shows the spectrum for a situation where an interfering line is observed beside the element of interest.

The analyst has many choices:

1. Select an alternate interferent free line.
2. Move or turn off the background points to negate the interferent
3. Use an interfering element correction (IEC) to counteract the effect of the interfering element. This method is only applicable to direct spectral overlaps .



ACCESSORIES



ACCESSORIES

- Cetac ASX-520 Autosampler
- Cetac U-6000AT+ Ultrasonic Nebulizer
- Argon Humidifier
- Laser – Solid sampling device (requires dedicated RS232 on Data
- High Solids Sample Introduction kit
- HF Acid Sample Introduction kit
- Organics Sample Introduction Kit
- Volatile Organics Sample Introduction kit



Autosampler

- Operation will be under full software control from the ICP system computer.
- The autosampler should be provided with all interconnecting cables required .
- The Autosampler should incorporate a peristaltic pump .
- In addition to rinsing between samples.



Ultrasonic nebulizer

- An ultrasonic nebulizer allow concentration of the sample aerosol and condensation of solvent through a 2 stage condenser to improve sensitivity by up to 20x.
- All connection cables and tubing shall be provided and installation should be a simple connection to the torch without involving the use of any tools.



Argon humidifier

- The Argon Humidifier is commonly used in ICP analyses involving samples with high dissolved solids concentration.
- Helping to prevent salt build-up inside the sample introduction system, the Argon Humidifier allows uninterrupted and maintenance free operation.



LASER — SOLID SAMPLING DEVICE

- U266 Macro laser—High Energy laser for direct analysis of refractory and difficult materials

Laser Ablation

- A laser ablation system shall be available for the analysis of solid samples.
- The system should have a large beam Nd-YAG laser operating at 266 nm and include a 30 – 1000 μm aperture imaged beam delivery system.



HIGH SOLIDS SAMPLE INTRODUCTION KIT

- Optimum kit for extended analysis of solutions containing up to 20 % m/v dissolved solids
- Use in conjunction with the argon humidifier (separate) for ultimate solids efficiency.



Inductively Coupled Plasma

-
- The image shows a blue carrying case for a portable water sampling system. Inside the case, several components are visible: a white plastic pump assembly, a black and white pump handle, a clear plastic tubing reel, a clear plastic collection container, and various connectors and fittings. The components are neatly arranged in the case, which is designed for easy transport and storage.

ORGANICS SAMPLE INTRODUCTION KIT

- Optimum kit for relatively non-volatile organics such as xylene, white spirit and kerosene
- The dedicated radial view ICP is the optimum choice for wear metals in used oil



VOLATILE ORGANICS SAMPLE INTRODUCTION KIT

- Jacketed, baffled spray chamber for volatile organics such as ketones, alcohols and aldehydes
- Additional chiller will be required to cool the *spray chamber*



ISO MIST

A solvent with a high vapour pressure

1. Volatile organics kit
2. Glass concentric nebuliser
3. IsoMist temperature controlled spray chamber
4. 1mm centre tube
5. Solvent flex pump tubing

Plasma parameters

Spray chamber temperature	-5C
Nebuliser gas flow	0.4 l/min
Auxiliary gas flow	1.5 l/min
Coolant gas flow	12 l/min
RF power	1150W



Hydride generation system

- Hydride Accessory for iCAP 7400—Hydride generation accessory For sub-ppb detection limits on As, Bi, Hg, Sb, Se, Sn and Te
- A hydride generation system shall be available to allow mixing of the sample with sodium borohydride solution and separation of the gaseous hydride products.
- The accessory should be provided with all the tubing and connection pieces to allow easy integration into the sample introduction system.



VAPOR KIT

Sophisticated new design Provides:

- Mixing manifold
- Reaction zone
- Phase separation zone
- Semi-permeable membrane
- Pumped drain



Maintenance

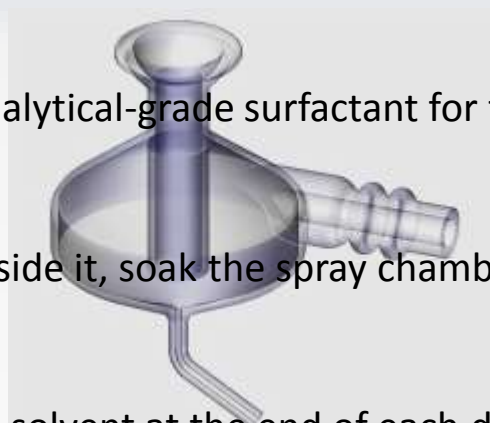
PREVENTATIVE

- All electrical supplies, gas supplies and extraction must be checked to ensure local health and safety guidelines and regulations are complied with.
- The gas and cooling water should be checked for leaks at regular intervals.
- An effective maintenance plan would include replacing the cooling fluid with new fluid periodically depending on the usage of your instrument, and also to ensure that any air filters and water filters in the chiller are kept clean.
- If gas filters are fitted to your purge and plasma gas inlets, these must be checked for cleanliness to prevent loss of instrument performance.
- If the filters appear dirty, replace them and check the quality of your gas supplies.



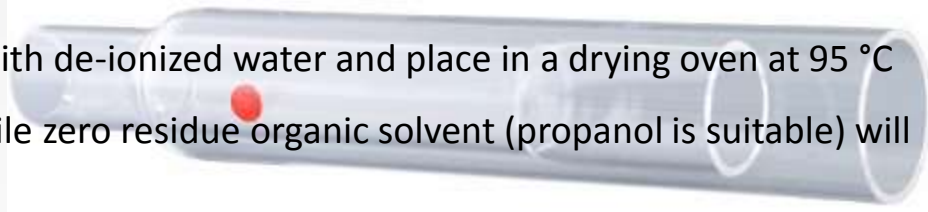
CLEANING

- ICP Components contaminated with sample residues should be cleaned.
- Any spillage on the external covers or within the sample introduction areas should be cleaned up with a soft cloth moistened with a mild detergent solution.
- Do not use any solvent based cleaners.
- If spray chamber become greasy soak the in a dilute analytical-grade surfactant for five minutes then rinse.
- If the spray chamber becomes dirty or deposits form inside it, soak the spray chamber in cold aqua regia for two hours then rinse.
- Rinse the nebulizer with deionized water or the organic solvent at the end of each day, or aspirate a cleaning solution through. If it is blocked, use an Eluo™ or similar to get rid of the blockage. Do not put the concentric nebulizer in an ultrasonic bath or heat it in oven .
- POP **“Purged Optical Path”** Clean the POP window using a lint free cloth and clean water. Repeat the cleaning process using methanol then, when dry, re-insert the POP



TORCH CLEANING

- Allow at least 10 minutes for any hot components to cool before removing them.
- Soak the torch in a dilute analytical-grade surfactant for five minutes to remove salt deposits.
- To remove metallic deposits from the tip, separate the torch quartz section, immerse the tip of the torch in acid (a mixture of nitric and hydrochloric similar to aqua regia).
- After cleaning, rinse the torch with de-ionized water and place in a drying oven at 95 °C until it is dry. Rinsing with a volatile zero residue organic solvent (propanol is suitable) will aid drying.
- To clean the torch of carbon deposits, place the torch in a muffle furnace and heat to 750 °C. Open the door for a few seconds to allow air to enter, close and allow the oven to reach 750 °C again. Repeat this several times to remove all the carbon. Allow the furnace to cool over several hours, as this will prevent stress building up in the quartz.



Applications



APPLICATIONS

1. **Environmental Analyses Applications**
2. **Petrochemical Analyses**
3. **Metallurgical analyses**
4. **Geological analyses**
5. **Foodstuffs analyses**
6. **And more.**



1. ENVIRONMENTAL ANALYSES APPLICATIONS

1. Waters – potable, natural, effluent, wastewaters, sea and coastal waters
2. Soils – soils, sediments, foliage, biota, contaminated land, landfill sites
3. Sludges – solid and digested waste
4. Air – chimney exhaust filters, air filters of contaminated sites, dusts



2. PETROCHEMICAL ANALYSES

1. Specifically oils & greases,
2. Additives, pigments, intermediates
3. Petrochemical applications at refineries, wear metal analysis for industrial fleets, heavy industry by-products
4. Paints and inks

Typically uses a Radial iCAP



ELEMENTS OF INTEREST

1. Additive Elements (typical) High concentrations, accuracy is important-Ba, Ca, Mg, P, S, Zn
2. Wear Metals (typical) Moderate accuracy, trend analysis
3. Al, Cd, Cr, Cu, Fe, Pb, Mn, Mo, Ni, Ag, Sn, Ti, V
4. Contaminants (typical) -B, K, Na, Si,
5. Typical Analysis -Al, Ca, Cr, Cu, Fe, Mg, Mo, Na, P, Pb, Si, Sn, Zn



ORGANIC PLASMAS

- An organic plasma is simply a plasma which has a organic solvent being introduced into it rather than an aqueous solvent.
- They appear green
- The edges of the plasma are more clearly defined when compared to aqueous plasmas



3. METALLURGICAL ANALYSES

- **Steels and Alloys**
- **Precious metals – PGMs**
- **Bulk Materials – bronzes and brasses**
- **Traces – contaminants**



Typically uses a Radial iCAP

4. GEOLOGICAL ANALYSES

- Rock samples, sediments, slags, ceramics, cements
- Survey work, quality control, raw material screening
- Robust
- Matrix tolerant
- Stability
- Detection limits (traces)



Typically uses a Radial iCAP

5. FOODSTUFFS ANALYSES

- Bulk materials, raw and finished products in food production
- Trace analysis of micronutrients
- Toxins - contamination of land and sea
- Animal feed
- Crop analysis

Typically uses a Duo iCAP



SAMPLE PREPARATION – FOODSTUFFS

- **Microwave digestion – bulk materials**
- **Wet or dry ashing – high TDS liquids**
- **Acid digestion – baby milk formula**
- **Direct analysis – aqueous or water soluble organics**



THANK

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