

# Technical Note

## A New Compact Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) Using Ultrasonic Nebulization for Enhanced Detection of Trace Elements

### INTRODUCTION

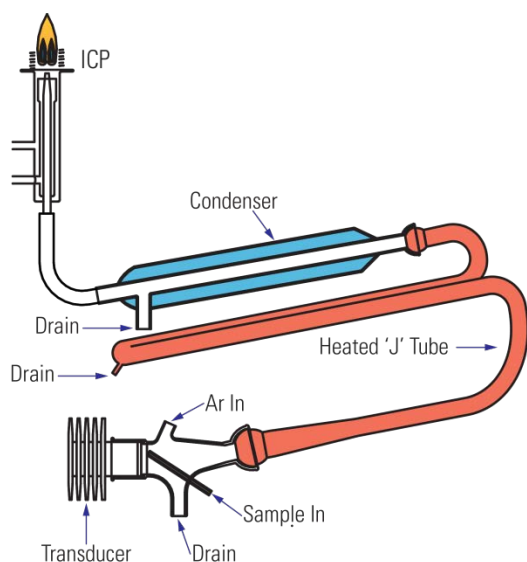
The PerkinElmer Avio 200 ICP-OES is a new fast scanning atomic emission spectrometer that features a compact design with Flat Plate™ plasma technology. The patented Flat Plate™ technology provides robust and stable plasma operating conditions at half the argon consumption of all contemporary ICP-OES instruments. In addition, the Avio 200 has a patented Dual View capability that measures every wavelength with no loss of light or sensitivity. A CCD detector measures the wavelength range around the analyte emission line for simultaneous background correction.

This technical note will examine the use of a commercial ultrasonic nebulizer (USN) with the PerkinElmer Avio 200 ICP-OES. Ultrasonic nebulization offers improved element transport efficiency versus the conventional pneumatic nebulizers that are standard kit with ICP-OES instruments. Figures of merit will include signal enhancement, calibration, and element detection limits. Of particular interest is improved detection of more difficult elements such as arsenic, selenium, and phosphorus.

### INSTRUMENTATION

ICP-OES: **PerkinElmer Avio 200**

Ultrasonic Nebulizer: **Teledyne CETAC U5000AT<sup>+</sup>**



**Teledyne CETAC U5000AT<sup>+</sup> Schematic:** The U5000AT<sup>+</sup> consists of a piezoelectric transducer, a heated u-tube, and electrothermally cooled condenser



**PerkinElmer Avio 200 ICP-OES & Teledyne CETAC U5000AT<sup>+</sup> Ultrasonic Nebulizer**

## OPERATING CONDITIONS

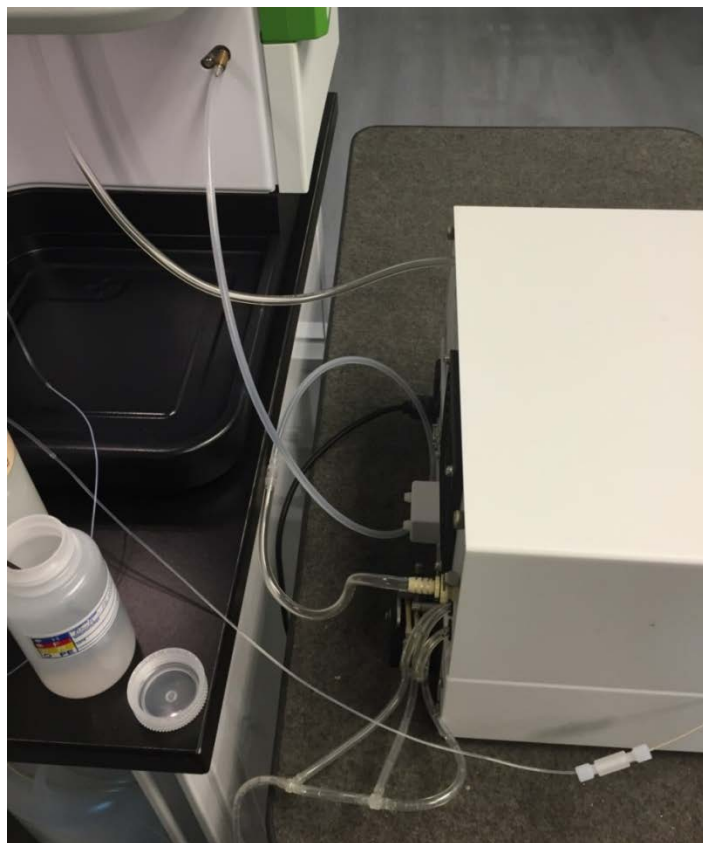
Parameter	Standard Setup	U5000AT <sup>+</sup> USN
ICP Power	1500 W	1500 W
Plasma Gas	8.0 L/min	8.0 L/min
Aux. Gas	0.2 L/min	0.2 L/min
Nebulizer Gas	0.70 L/min	0.50 L/min
Uptake Rate	1.5 mL/min	1.5 mL/min
Nebulizer Type	Meinhard K	piezoelectric
Spray Chamber	baffled cyclonic	conical
Heater Temp	NA	140°C
Cooler Temp	NA	3°C
Viewing	axial	axial
Integration Time	10s	10s
Replicates	3	3

## BLANK AND STANDARDS PREPARATION

Using a double-distilled grade of HNO<sub>3</sub>, a 1% HNO<sub>3</sub> reagent blank and four multi-element calibration standards in 1% HNO<sub>3</sub> were prepared by weight in pre-cleaned low-density polyethylene (LDPE) bottles. Standard concentrations were 5, 10, 20, and 50 µg/L.

## ULTRASONIC NEBULIZER SETUP, CALIBRATION, AND DETECTION LIMITS

The standard nebulizer and spray chamber were first removed from the Avio 200 ICP-OES. Using an interface kit, the ultrasonic nebulizer was connected to the Avio 200 via a nebulizer gas line and a sample out line. The nebulizer gas line contains a quick connect fitting for connection to the Avio 200 nebulizer gas port; the sample out line has a 12/5 glass adapter for direct connection to the ICP torch. The host ICP-OES peristaltic pump was used to pump sample solution to the ultrasonic nebulizer transducer; no computer control is required for the ultrasonic nebulizer. The yellow “operate” button on the front of the U5000AT<sup>+</sup> is pressed to start aerosol production.



### Connections between U5000AT<sup>+</sup> Ultrasonic Nebulizer and Avio 200 ICP-OES

The 1% HNO<sub>3</sub> reagent blank and four multi-element calibration standards (5, 10, 20, and 50 µg/L) were run with both the standard nebulizer and the ultrasonic nebulizer to establish calibration curves. After calibration, the 1% HNO<sub>3</sub> blank was measured three times, with each measurement being an average of three replicates, establishing a detection limit (DL). Detection limits are calculated as 3x the average standard deviation of the three 1% HNO<sub>3</sub> blank measurements.

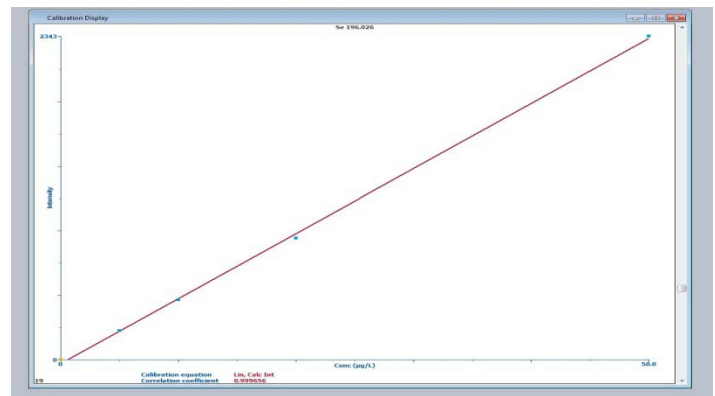
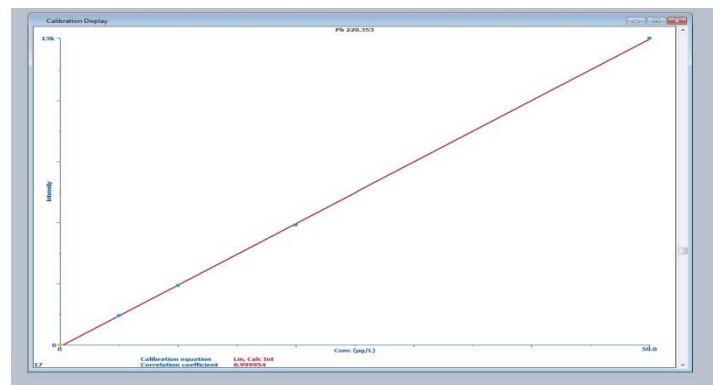
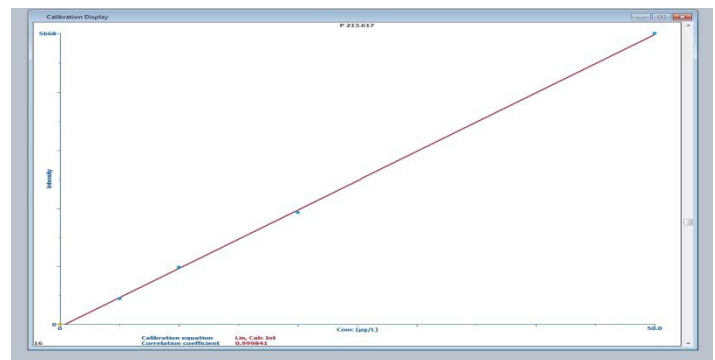
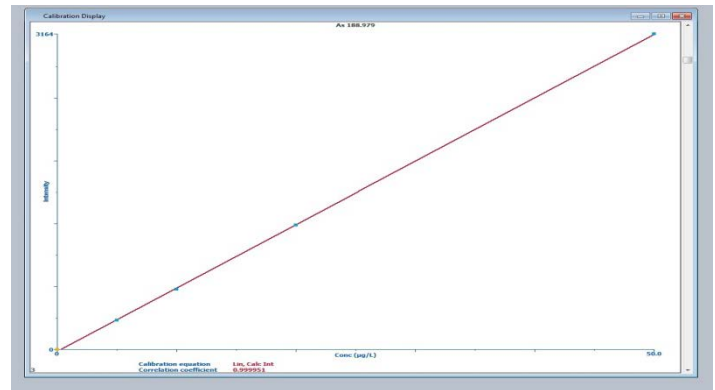
## ELEMENT SIGNAL INTENSITY COMPARISON

The following table shows a comparison (standard nebulizer vs. ultrasonic nebulizer) of element signal intensities for the 50 ppb standard. Signal enhancement with the ultrasonic nebulizer ranges from 4.6x to 14.0x, with an average enhancement of 8.5x.

Element	Wavelength (nm)	Intensity Std. Neb. 50ppb	Intensity USN 50ppb	Factor
Ag	328.068	67368	944539	14.0
Al	396.153	49244	586868	11.9
As	188.979	424	3163	7.4
Ba	233.527	45380	420223	9.2
Be	313.107	659085	4476520	6.7
Bi	223.061	1436	12806	8.9
Cd	226.502	24346	145310	5.9
Co	228.616	16541	137430	8.3
Cr	267.716	27012	249341	9.2
Cu	327.393	51742	406051	7.8
Fe	259.939	59496	469094	7.8
Mg	285.213	91197	927317	10.1
Mn	257.610	291711	2609085	8.9
Mo	202.031	4876	42545	8.7
Ni	231.604	10129	80581	7.9
P	213.617	597	5668	9.4
Pb	220.353	1340	12844	9.5
Sb	206.836	862	7529	8.7
Se	196.026	331	2342	7.0
Sn	189.927	427	3790	8.8
Sr	421.552	3645208	29875877	8.1
Ti	334.940	209064	1759949	8.4
Tl	290.801	522	2422	4.6
V	292.402	23339	189517	8.1
Zn	206.200	4602	34294	7.4

## CALIBRATION CURVES USING THE ULTRASONIC NEBULIZER

Calibration curves using the ultrasonic nebulizer for less sensitive elements such as As, P, Pb, and Se are given below; correlation coefficients range from 0.9996 to 0.9999.



## DETECTION LIMIT COMPARISON

The table below shows a comparison (standard nebulizer vs. ultrasonic nebulizer) of detection limits as described previously. In this example detection limits are lowered via the ultrasonic nebulizer from 2.0x to 125x, with an average enhancement of 18.5x. Variation in observed detection limits can be caused by numerous factors, including the background spectra complexity, elevated blanks, and integration times.

Element	Wavelength (nm)	Det. Limit Std. Neb. (µg/L)	Del. Limit USN (µg/L)	Factor
Ag	328.068	0.6	0.02	30
Al	396.153	1	0.04	25
As	188.979	1	0.4	2.5
Ba	233.527	0.03	0.008	3.7
Be	313.107	0.09	0.002	45
Bi	223.061	1	0.5	2
Cd	226.502	0.1	0.02	5
Co	228.616	0.2	0.04	5
Cr	267.716	0.2	0.02	10
Cu	327.393	0.4	0.1	4
Fe	259.939	0.1	0.03	3.3
Mg	285.213	0.04	0.006	6.6
Mn	257.610	0.1	0.004	25
Mo	202.031	0.5	0.06	8.3
Ni	231.604	0.5	0.08	6.2
P	213.617	4	0.1	40
Pb	220.353	1	0.3	3.3
Sb	206.836	2	0.3	6.6
Se	196.026	2	0.6	3.3
Sn	189.927	2	0.2	10
Sr	421.552	0.05	0.0004	125
Ti	334.940	0.4	0.006	66
Tl	290.801	2	0.3	6.6
V	292.402	0.5	0.03	16.6
Zn	206.200	0.2	0.05	4

## SUMMARY

Use of an ultrasonic nebulizer with the PerkinElmer Avio 200 ICP-OES offers significantly increased analyte signal and subsequent lower detection limits for important elements such as As, Cd, P, Pb, Sb, Se, and Tl. Setup of the ultrasonic nebulizer is straightforward via a dedicated nebulizer gas inlet line and a sample out line; installation takes approximately 5 minutes. The ultrasonic nebulizer requires no computer control and the host ICP-OES peristaltic pump can be used to introduce samples.