CETAC U-5000^{+} Ultrasonic Nebulizer with Axial ICP-OES

Purpose of Study:	Investigate long-term signal stability (10 hours) for an advanced ultrasonic nebulizer coupled to an axial ICP-OES and compare detection limits with conventional pneumatic nebulization to ultrasonic nebulization.
Analytes:	As, Cd, Cu, Ni, Pb, Se, Tl
Matrix:	Drinking water from a municipal source (Omaha, NE USA)

Performance: Matrix levels from the drinking water are listed below in Table 1. The drinking water was acidified to 1% HNO_3 (high-purity grade) before analysis.

Drinking Water Matrix Levels

Element	Conc. (mg/L)
Na	59.3 ± 1.2
Ca	40.1 ± 1.9
Mg	13.5 ± 0.3
K	6.40 ± 0.45

*** Mean of 5 replicates; uncertainty is 3s.**
Municipal water source; Omaha, NE USA.

Table 1.

A comparison of detection limits between conventional nebulization and ultrasonic nebulization is given in Table 2 for selected elements. Overall, the improvement in detection limits is approximately 10 fold.

Comparison of Detection Limits (µg/L)

Element	Wavelength (nm)	GemCone	U5000AT+
Ag	328.068	0.3	0.02
As	188.979	1.5	0.2
Cd	214.438	0.3	0.02
Cr	267.716	0.3	0.02
Cu	324.754	0.2	0.02
Mn	257.610	0.05	0.003
Ni	231.604	0.3	0.02
Pb	220.353	0.8	0.08
Se	196.026	2.0	0.3
Tl	190.800	1.8	0.2
V	292.402	0.3	0.03
Zn	213.856	0.2	0.03

Notes: 10s integration time; detection limit equals 3x std. dev. of the blank concentration.

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Table 2.

Short-term stability (30 min.) was then investigated for seven elements spiked into the drinking water matrix (Table 3). Percent relative standard deviations (%RSD) for raw intensities were all under 1% (0.54% to 0.85%). Note that no internal standard was used.

CETAC U5000AT+ Short-Term Stability Selected Elements Spiked in Drinking Water

Analyte	Wavelength (nm)	Mean Intensity	% RSD (30min)
50ppb Ag	328.068	182,000	0.85
1ppm As	188.979	3860	0.69
50ppb Cd	226.502	38,600	0.71
50ppb Ni	231.604	12,800	0.63
500ppb Pb	220.353	17,100	0.68
1ppm Se	196.026	14,400	0.54
1ppm Tl	190.800	4960	0.67

Mean of 180 10s integrations (30min); 2-point background correction. No internal standard.

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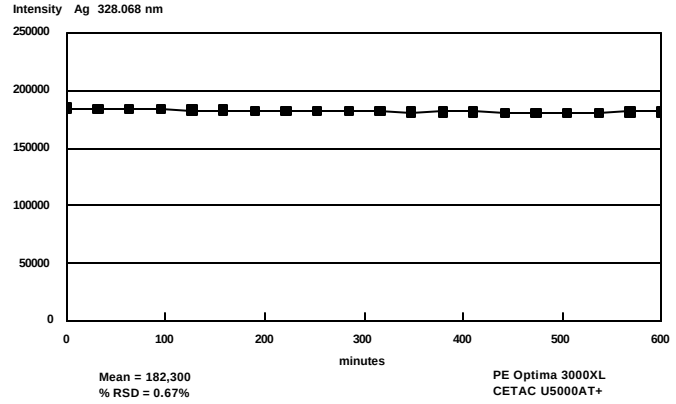
Table 3.

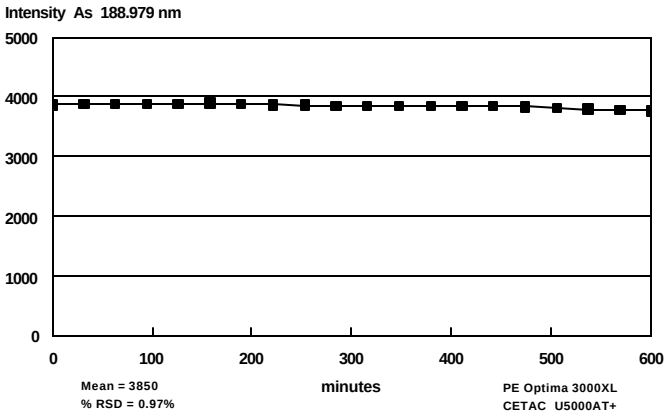
Long-term stability (10 hours) was then studied for the same seven elements. The mean of 180 replicate measurements (10 sec integration time) was recorded every 30 minutes and plotted in the following figures. Signal stability over the 10-hour period ranges from 0.40% to 1.08% relative standard deviation without use of an internal standard. See the next seven figures (below and the following two pages).

Finally, a stabilization and rinse-out test was performed with the CETAC U5000AT+. Signal stabilization (~12s) and rinse (~25s) times are both rapid as shown in the following figure.

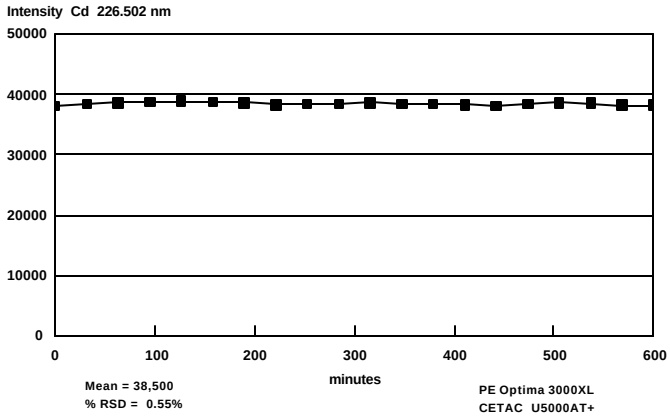
Long Term Stability Test
Ultrasonic Nebulization; 50ppb Ag in Drinking Water



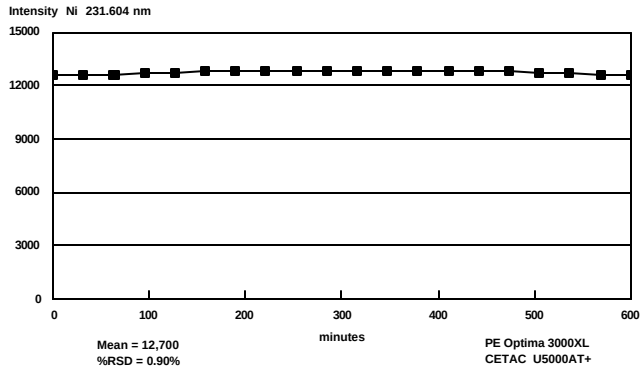
Long Term Stability Test
Ultrasonic Nebulization; 1ppm As in Drinking Water



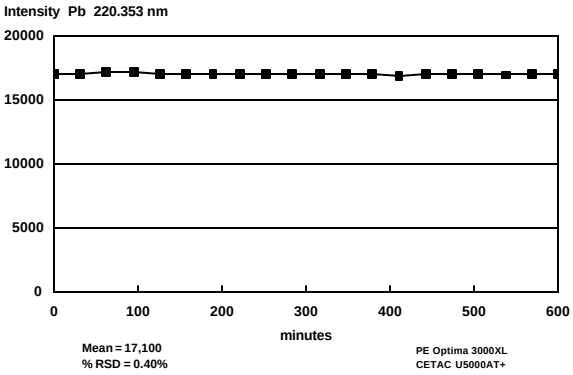
Long Term Stability Test
Ultrasonic Nebulization; 50ppb Cd in Drinking Water



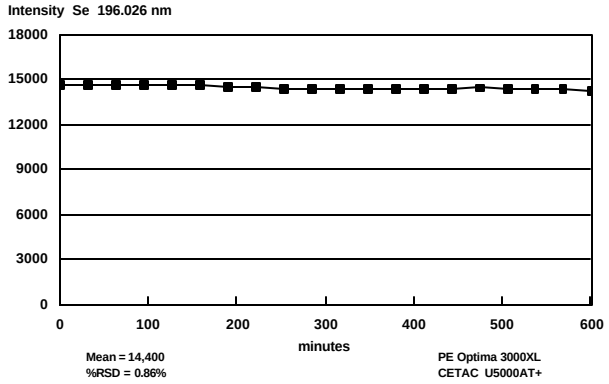
Long Term Stability Test
Ultrasonic Nebulization; 50ppb Ni in Drinking Water



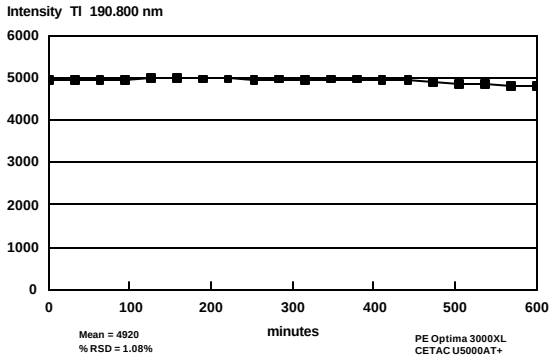
Long Term Stability Test
Ultrasonic Nebulization; 500ppb Pb in Drinking Water



Long Term Stability Test
Ultrasonic Nebulization; 1ppm Se in Drinking Water

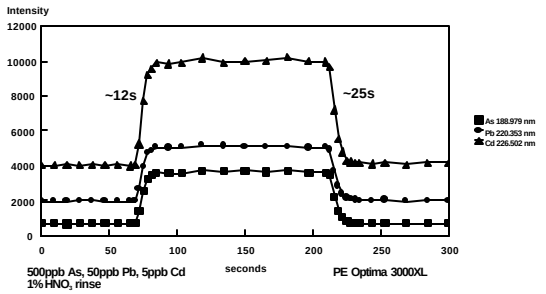


Long Term Stability Test
Ultrasonic Nebulization; 1ppm Tl in Drinking Water



Finally, a stabilization and rinse-out test was performed with the CETAC U5000AT+. Signal stabilization (~12s) and rinse (~25s) times are both rapid as shown in the following figure.

Stabilization and Rinse-Out
CETAC U5000AT+



Instrumentation: Perkin-Elmer OPTIMA 3000XL ICP-OES

CETAC U5000AT+ Ultrasonic Nebulizer

Operating Parameters:

ICP-OES

	Conventional Nebulization (GemCone Nebulizer)	Ultrasonic Nebulization (CETAC U5000AT^{+})
ICP Power:	1450W	1450W
Plasma gas flow:	15.0 L/min	15.0 L/min
Aux. gas flow:	1.0 L/min	1.0 L/min
Nebulizer gas flow:	0.6 L/min	0.7 L/min
Sample uptake rate:	2.0 mL/min	2.0 mL/min

Ultrasonic Nebulizer

Heater temperature: 140°C
Cooler temperature: 2°C

Principal of Operation:

Sample solution is pumped onto the quartz faceplate of an oscillating piezoelectric transducer. The oscillations disperse the sample solution into a fine aerosol which is transported by argon gas. The aerosol first passes through a heated tube to vaporize the solvent. The vaporized aerosol then passes through a thermo-electrically cooled condenser where a large fraction of the solvent is removed. The dried aerosol exits the ultrasonic nebulizer apparatus and enters the ICP torch for analysis.

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