



Arsenic Monitoring Technologies

The U.S. EPA Environmental Technology Verification (ETV) Program's Advanced Monitoring Systems (AMS) Center, one of six technology areas under ETV, is operated by Battelle under a cooperative agreement with EPA. The AMS Center has verified ten technologies for arsenic water monitoring¹ (see verification reports at <http://www.epa.gov/etv/verifications/vcenter1-21.html>).

Technology Description

Arsenic is typically measured using instruments that are bulky and expensive to operate and maintain in a fully-equipped laboratory. Field assays, in which lower sensitivities may be acceptable for purposes of sample screening or site surveys, strive for similar detection goals as fixed laboratory methods, are relatively inexpensive, and can produce a large number of screening results in a short time. The ETV-verified arsenic monitoring technologies are portable and designed for rapid on-site analysis of arsenic in water. They can be categorized into two monitoring technology classes: colorimetric and anodic stripping voltammetry. **Table 1** lists the ten verified arsenic monitoring technologies by technology class.

Colorimetric

The arsenic colorimetric test kits involve a chemical reaction that converts the arsenic compounds (mostly inorganic arsenic) present in the water into arsine gas. The arsine gas is exposed to a test strip, usually paper impregnated with a chemical that changes color from white to shades of yellow or brown with increasing arsine levels. The concentration of arsenic can be approximated using a calibrated color scale. Measurements with the colorimetric test kits are semiquantitative, unless the field kits are equipped with a portable colorimeter and/or a computer held scanner that allows for a quantitative determination of arsenic by quantifying the color change.

Anodic Stripping Voltammetry

Anodic stripping voltammetry (ASV) is an analytical technique in which analyte concentration is derived from the measurement of electric current as a function of applied potential. Analysis involves reducing the analyte of interest and plating the analyte onto an electrode by applying a negative potential for a specific period of time. The deposition serves to concentrate the analyte from the solution onto the electrode in the metallic form. After deposition, the potential is scanned toward positive potentials and the analyte is then stripped off (i.e., oxidized), brought back into solution and measured quantitatively relative to known standard solutions.

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Arsenic and Its Regulatory Background at a Glance

Arsenic occurs naturally in rocks, soil, water, air, plants, and animals. It can be released into water, including drinking water, through natural processes such as erosion, or through human actions, including agricultural applications (fungicides or rodenticides), mining, or disposal of arsenic-laden consumer products (wood preservative, paints, dyes, soaps, and semiconductors). Studies have linked long-term exposure to arsenic at various levels in drinking water to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. Non-cancer effects of ingesting arsenic include cardiovascular, pulmonary, immunological, neurological, and endocrine (e.g., diabetes) effects.

In January 2001, based in part on the National Academies of Science recommendation and to protect consumers against the effects of long-term chronic exposure to arsenic in drinking water, EPA set a new drinking water standard for arsenic at 10 parts per billion (ppb) with compliance by all public water systems required by January 2006 (66 FR 6976).

Table 1.
Verified Arsenic Monitoring Technologies

Colorimetric Test Kits	Anodic Stripping Voltammetry (ASV)
Technology Name	Technology Name
Industrial Test Systems, Inc. Quick™ II	Monitoring Technologies International, Pty. Ltd. PDV 6000 with VAS Version 2.1 Software
Industrial Test Systems, Inc. Quick™ Ultra Low II	TraceDetect Nano-Band™ Explorer
Industrial Test Systems, Inc. Quick™ Low Range	TraceDetect SafeGuard Trace Metal Analyzer
Industrial Test Systems, Inc. Quick™ Low Range II	
Industrial Test Systems, Inc. Quick™	
Peters Engineering AS 75	
Envitop Ltd. As-Top Water	

¹The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. Verification does not imply product approval or effectiveness. ETV does not endorse the purchase or sale of any products and services mentioned in this document.

Table 2. Summary of Performance for Arsenic Monitoring Technologies

Technology ^A	Accuracy ^B (% relative bias)	Precision ^B (% relative standard deviation)	Linearity ^B			False Positive Rate ^C (%)	False Negative Rate ^C (%)	Method Detection Limits (MDL) ^B (ppb)
			slope	Intercept	r ²			
A Unit 1	-21 to 7	3 to 20	0.808	0.060	0.9936	0	4	3.75
A Unit 2	-21 to -8	6 to 20	1.005	1.618	0.9942	0	22	2.87
B	-33 to 10	16 to 24	0.88	-1.82	0.9779	0	19	7
C Unit 1	-46 to -4	6 to 16	0.77	1.22	0.9934	0	42	8.6
C Unit 2	-51 to 31	3 to 15	0.91	0.59	0.9955	0	38	5.8
D	1 to 64	3 to 37	1.29	-5.56	0.988	13	7	14.2
E	-24 to 18	0 to 14	0.92	0.22	0.9948	0	14	2.9
F	-14.5 to 239	0 to 3	0.83	2.61	0.9992	3	0	3.1
G	-47 to -8	10 to 55	0.79	-0.3	0.9904	0	62	1.2
H	8 to 83	0 to 29	0.88	-0.45	0.988	0	5	Not Calculated
I Unit 1	2 to 70	0 to 24	0.80	5.12	0.979	3	0	Not Calculated
I Unit 2	2 to >310	12 to >71	1.28	5.70	0.923	13	0	28
J	2 to 2900	0 to 111	0.55	2.97	0.66	18	30	Not Calculated

^A Because the ETV Program does not compare technologies, the performance results shown in this table do not identify the technologies associated with each result and are not in the same order as the list of technologies in Table 1.

^B Technical operator sample results of performance test samples only

^C Technical operator sample results of performance test samples, quality control samples, and environmental samples, relative to the 10 ppb maximum contaminant level for arsenic in drinking water



Verified arsenic monitoring technology — colorimetric

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Test Design and Verification Results

Arsenic measurements were compared to those from a laboratory-based reference method—inductively coupled plasma mass spectrometry (ICP-MS) performed according to EPA Method 200.8. Technology performance was tested by analyzing performance test (PT) samples, quality control (QC) samples, and environmental samples for the evaluation of test parameters. Accuracy and linearity were assessed by comparing technology results to those from the reference method. Four aliquots of PT samples and environmental samples were analyzed to assess precision. Seven aliquots of a PT sample (five times the vendor-stated detection limit) were analyzed

to assess the detection limit. Potential matrix interference effects were assessed with PT samples of 10 ppb arsenic concentration that contained both low levels and high levels of potentially interfering substances. Some technologies were verified using two identical units. Results from the two units were statistically compared to evaluate inter-unit reproducibility. Operator bias was assessed by statistically comparing data from two operators (technical and non-technical). The rates of false positive and false negative results were evaluated relative to the 10 ppb level of detection. **Table 2** provides a summary of performance data for some of the test parameters.



Verified arsenic monitoring technology — ASV

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References

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U.S. EPA Arsenic in Drinking Water, <http://www.epa.gov/safewater/arsenic/>.

Monitoring Arsenic in the Environment: A Review of Science and Technologies for Field Measurements and Sensors, <http://www.epa.gov/superfund/programs/aml/tech/news/asreview.htm>.