THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

Battelle
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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Arsenic Test Kit**	
APPLICATION:	**ANALYSIS OF ARSENIC IN WATER**	
TECHNOLOGY NAME:	**Quick™**	
COMPANY:	**Industrial Test Systems, Inc.**	
ADDRESS:	**1875 Langston Street** **Rock Hill, SC 29730**	**PHONE: (803) 329-9712** **FAX: (803) 329-9743**
WEB SITE:	**www.sensafe.com**	
E-MAIL:	**its@cetlink.net**	

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; with stakeholder groups that consist of buyers, vendor organizations, and permitters; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Advanced Monitoring Systems (AMS) Center, one of six technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of four portable analyzers for arsenic in water. This verification statement provides a summary of the test results for the Industrial Test Systems, Inc. Quick™ arsenic test kit.

VERIFICATION TEST DESCRIPTION

The Quick™ test kit is an inexpensive, portable, rapid device designed for on-site analysis of arsenic in water. The Quick™ test kit was verified in terms of its performance on the following parameters: accuracy, precision,

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TECHNOLOGY TYPE:	**ARSENIC TEST KIT**	
APPLICATION:	**ANALYSIS OF ARSENIC IN WATER**	
TECHNOLOGY NAME:	**Quick™ II**	
COMPANY:	**Industrial Test Systems, Inc.**	
ADDRESS:	**1875 Langston Street** **Rock Hill, SC 29730**	**PHONE: (803) 329-9712** **FAX: (803) 329-9743**
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The Advanced Monitoring Systems (AMS) Center, one of seven technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of portable analyzers for arsenic in water. This verification statement provides a summary of the test results for the Industrial Test Systems, Inc., Quick™ II test kit for measuring arsenic in water.

VERIFICATION TEST DESCRIPTION

The Quick™ II test kit is a portable, rapid device designed for on-site analysis of arsenic in water. The Quick™ II test kit was verified in terms of its performance on the following parameters: accuracy, precision, linearity, method detection limit (MDL), matrix interference effects, operator bias, inter-unit reproducibility, and rate of false positives/false negatives. All preparation and analyses were performed according to the manufacturer's recommended procedures. Results from the Quick™ II test kit were compared to those from the reference method

to assess accuracy, linearity, and detection limit. Multiple aliquots of performance test samples and environmental samples were analyzed to assess precision. Matrix interference effects were assessed by challenging the test kit with performance test samples of known arsenic concentrations containing both low-level and high-level interferences. Identical sets of samples were analyzed independently by two separate operators (a technical and a non-technical Battelle staff member) to evaluate operator bias. All samples were analyzed using two Quick™ Arsenic Scan and two Compu-Scan units to evaluate inter-unit reproducibility. False positives and negatives were evaluated relative to the 10-ppb maximum contaminant level for arsenic in drinking water. In addition to the analytical results, the time required for sample analysis and operator observations concerning the use of the test kit (e.g., frequency of calibration, ease of use, maintenance) were recorded.

Three types of samples were used in the verification test: quality control (QC) samples, performance test (PT) samples, and environmental water samples. The QC and PT samples were prepared from National Institute of Standards and Technology traceable purchased standards. The environmental water samples were collected from various drinking water and surface water sources. All samples were analyzed using the Quick™ II test kits and by a laboratory reference method.

QA oversight of verification testing was provided by Battelle. Battelle QA staff conducted a data quality audit of 10% of the test data, a performance evaluation audit, and a technical systems audit of the procedures used in this verification.

TECHNOLOGY DESCRIPTION

The following description was provided by the vendor and does not represent verified information.

The optimal detection range for the Quick™ II test kit is below 10 ppb arsenic. Dilution instructions are provided for samples with arsenic levels above 15 ppb. The recommended temperature range for sample analysis is 24°C to 30°C. A modified testing protocol is available for sample temperatures below this range. To perform arsenic analyses with the Quick™ II test kit, the water sample to be tested is mixed in the supplied reaction vessel with reagent #1 (tartaric acid with rate enhancers) to acidify the water sample. Reagent #2, an oxidizer (potassium peroxymonosulfate), is added to remove hydrogen sulfide interference. The test tolerates up to 2 ppm hydrogen sulfide without interference. Zinc powder, reagent #3, is added to reduce inorganic arsenic compounds (As^{+3} and As^{+5}) to arsine gas. As arsine gas is generated and comes in contact with the test strip, the mercuric bromide indicator on the test strip changes color from white to shades of yellow or brown. Material Safety Data Sheets (MSDS) for all reagents and test strips are provided with each test kit. The MSDSs include information on how to safely handle the reagents and test strips, including instructions for exposure controls and personal protection.

Once the reaction is completed, the test strip is removed and visually compared to a color chart to obtain a semi-quantitative measure of the arsenic concentration in the tested sample. The color chart consists of a series of color blocks that correspond to concentrations ranging from 2 ppb to >150 ppb. The test strip may also be read with the Quick™ Arsenic Scan hand-held instrument, which operates on the same principle as a colorimeter and provides a quantitative result. The Quick™ Arsenic Scan is calibrated weekly using a calibration card provided by the manufacturer. Quantitative results may also be obtained from the test strip with a portable Compu-Scan scanner and laptop system. The scanned test strip image is converted to an arsenic concentration using the Home Port Computer System Arsenic Program Revision 5b software. The scanner is calibrated by the manufacturer. The Quick™ Arsenic Scan and Compu-Scan are not provided with the Quick™ II test kit as a standard feature. The standard test kit with the color chart was the subject of this verification test; however, results for the Quick™ Arsenic Scan and Compu-Scan were also provided. The Quick™ II test kits are available in sets of 50 tests. The typical shelf life of the kits is 24 months.

VERIFICATION OF PERFORMANCE

Accuracy: The bias for the Quick™ II color chart ranged from -61% to 10% for the technical operator and from -77% to 96% for the non-technical operator. The bias for the Quick™ Arsenic Scan ranged from -78% to -4% for the technical operator and from -85% to -22% for the non-technical operator. The bias for the Compu-Scan ranged from -71% to 96% for the technical operator and from -82% to 108% for the non-technical operator. The overall agreement for the color chart results based on an assessment of whether the result was assigned to the correct

color block indicated that the total percent agreement was 68% for the technical operator and 72% for the non-technical operator.

Precision: For the technical operator, precision expressed as a relative standard deviation (RSD) ranged from 16% to 24% for the color chart, 11% to 44% for the Quick™ Arsenic Scan and 10% to 58% for the Compu-Scan. For the non-technical operator, RSDs ranged from 0% to 38% for the color chart, 13% to 38% for the Quick™ Arsenic Scan and 16% to 108% for the Compu-Scan.

Linearity: The linearity of response was evaluated by plotting the test kit results against the reference analysis results for the PT samples. The equations for the linear regressions that were performed to evaluate linearity are as follows, where x is the reference method concentration and y is the test kit concentration:

Color chart, technical operator	$y = 0.88x - 1.82$, R = 0.9779
Color chart, non-technical operator	$y = 0.52x + 3.37$, R =0.9822
Quick™ Arsenic Scan #1, technical operator	$y = 0.75x - 2.42$, R =0.9340
Quick™ Arsenic Scan #2, technical operator	$y = 0.66x - 0.30$, R =0.9565
Quick™ Arsenic Scan #1, non-technical operator	$y = 0.59x + 0.095$, R =0.9828
Compu-Scan #1, technical operator	$y = 0.85x - 2.67$, R =0.9301
Compu-Scan #2, technical operator	$y = 1.39x - 5.12$, R =0.9117
Compu-Scan #1, non-technical operator	$y = 0.73x - 0.55$, R =0.9787

Method Detection Limit: The MDLs calculated using precision data from seven replicates of a low-level spiked sample ranged from 3.6 ppb to 7 ppb for the color chart, 4.5 ppb to 6.1 ppb for the Quick™ Arsenic Scan, and 3.7 ppb to 18.2 ppb for the Compu-Scan.

Matrix Interference Effects: Low and high levels of interferents did not appear to affect the detection of arsenic. Biases for these samples were similar to those calculated for PT samples containing arsenic only.

Operator Bias: Measurements for the color chart, Quick™ Arsenic Scan, and Compu-Scan done by the technical operator tended to be higher than for the non-technical operator. Paired t-tests indicated that the results were not significantly different at a 5% significance level for the Quick™ Arsenic Scan and Compu-Scan results. Color chart results for the technical and non-technical operators were significantly different.

Inter-Unit Reproducibility: The results for the two Quick™ Arsenic Scan units almost exactly corresponded, indicating that the performance of the two units was very similar. The data for the Compu-Scan units showed more scatter, and Unit #2 tended to return higher results than Unit #1. Paired t-tests of the two sets of data indicated that the Quick™ Arsenic Scan results were not significantly different at a 5% significance level whereas the results for the two Compu-Scan units were significantly different.

Rate of False Positives/False Negatives: The false positive rates for the technical and non-technical operators using the color charts and Quick™ Arsenic Scan units were all 0%. The false positive rates for the Compu-Scan units were 3% and 9% for the technical operator (Units #1 and #2) and 0% for the non-technical operator (Unit #1). The false negative rates for the non-technical and technical operators using the color charts were 19% and 24%, respectively. The false negative rates for the Quick™ Arsenic Scan units were 33% and 19% for the technical operator (Units #1 and #2, respectively) and 29% for the non-technical operator (Unit #1). The false negative rates for the Compu-Scan units were 38% and 10% for the technical operator (Units #1 and #2, respectively) and was 14% for the non-technical operator (Unit #1).

Other Factors: The Quick™ II test kits were easy to use and readily transportable to the field. The time to analyze one sample is approximately 15 minutes at a temperature range of 24°C to 30°C; longer reaction times are required for samples below this range. Two samples can be run concurrently without difficulty. The sample bottles were of moderate size and were relatively easy to handle. The test kit components were reliable. Dilution of samples with arsenic concentrations exceeding the optimal detection range may be a source of error and reduce the accuracy and precision of the associated results because of the difficulty in performing accurate dilution in a field setting. The cost for a 50-sample test kit with a color chart is listed as $219.99. Replacement reagents and supplies are not available; kits are provided as a complete set because reagents, test strips, and color charts are

made to perform optimally with each other, according to the vendor. The Quick™ Arsenic Scan and Compu-Scan are available as options for an additional cost of $1,599.99 each.

signed by Gabor J.Kovacs	8/7/03	signed by Gary J. Foley	9/30/03
Gabor J. Kovacs	Date	Gary J. Foley	Date
Vice President		Director	
Environmental Sector		National Exposure Research Laboratory	
Battelle		Office of Research and Development	
		U.S. Environmental Protection Agency	

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**ARSENIC TEST KIT**	
APPLICATION:	**ANALYSIS OF ARSENIC IN WATER**	
TECHNOLOGY NAME:	**Quick™ Low Range**	
COMPANY:	**Industrial Test Systems, Inc.**	
ADDRESS:	**1875 Langston Street** **Rock Hill, SC 29730**	**PHONE: (803) 329-9712** **FAX: (803) 329-9743**
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The Advanced Monitoring Systems (AMS) Center, one of seven technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of portable analyzers for arsenic in water. This verification statement provides a summary of the test results for the Industrial Test Systems, Inc. Quick™ Low Range test kit for measuring arsenic in water.

VERIFICATION TEST DESCRIPTION

The Quick™ Low Range test kit is a portable, rapid device designed for on-site analysis of arsenic in water. The Quick™ Low Range test kit was verified in terms of its performance on the following parameters: accuracy, precision, linearity, method detection limit (MDL), matrix interference effects, operator bias, inter-unit reproducibility, and rate of false positives/false negatives. All preparation and analyses were performed according to the manufacturer's recommended procedures. Results from the Quick™ Low Range test kit and Quick™ Arsenic Scan detection device were compared to those from the reference method to assess accuracy, linearity, and detection limit. Multiple aliquots of performance test samples and environmental samples were analyzed to assess precision. Matrix interference effects were assessed by challenging the test kit with performance test samples of known arsenic concentrations containing both low-level and high-level interferences. Identical sets of samples were analyzed independently by two separate operators (a technical and a non-technical Battelle staff member) to evaluate operator bias. All samples were analyzed using two Quick™ Arsenic Scan units to evaluate inter-unit reproducibility. False positives and negatives were evaluated relative to the 10-ppb maximum contaminant level for arsenic in drinking water. In addition to the analytical results, the time required for sample analysis and operator observations concerning the use of the test kit (e.g., frequency of calibration, ease of use, maintenance) were recorded.

Three types of samples were used in the verification test: quality control (QC) samples, performance test (PT) samples, and environmental water samples. The QC and PT samples were prepared from National Institute of Standards and Technology traceable purchased standards. The environmental water samples were collected from various drinking water and surface water sources. All samples were analyzed using the Quick™ Low Range test kits and by a laboratory reference method.

QA oversight of verification testing was provided by Battelle. Battelle QA staff conducted a data quality audit of 10% of the test data, a performance evaluation audit, and a technical systems audit of the procedures used in this verification.

TECHNOLOGY DESCRIPTION

The following description was provided by the vendor and does not represent verified information.

The optimal detection range for the Quick™ Low Range test kit is below 20 ppb arsenic. Dilution instructions are provided for samples with arsenic levels above 30 ppb. The recommended temperature range for sample analysis is 24°C to 30°C. A modified testing protocol is available for sample temperatures below this range. To perform arsenic analyses with the Quick™ Low Range test kit, the water sample to be tested is mixed in the supplied reaction vessel with reagent #1 (tartaric acid with rate enhancers) to acidify the water sample. Reagent #2, an oxidizer (potassium peroxymonosulfate), is added to remove hydrogen sulfide interference. The test tolerates up to 2 ppm hydrogen sulfide without interference. Zinc powder, reagent #3, is added to reduce inorganic arsenic compounds (As^{+3} and As^{+5}) to arsine gas. As arsine gas is generated and comes in contact with the test strip, the mercuric bromide indicator on the test strip changes color from white to shades of yellow or brown. Material Safety Data Sheets (MSDS) for all reagents and test strips are provided with each test kit. The MSDSs include information on how to safely handle the reagents and test strips, including instructions for exposure controls and personal protection.

Once the reaction is completed, the test strip is removed and visually compared to a color chart to obtain a semi-quantitative measure of the arsenic concentration in the tested sample. The color chart consists of a series of color blocks that correspond to concentrations ranging from 3 ppb to >80 ppb. The test strip may also be read with the Quick™ Arsenic Scan hand-held instrument, which operates on the same principle as a colorimeter and provides a quantitative result. The Quick™ Arsenic Scan is calibrated weekly using a calibration card provided by the manufacturer. The Quick™ Arsenic Scan is not provided with the test kit as a standard feature. The standard test kit with the color chart was the subject of this verification test; however, results for the Quick™ Arsenic Scan are also provided. The kits are available in two sizes: two tests and 50 tests. The typical shelf life of the kits is 24 months.

VERIFICATION OF PERFORMANCE

Accuracy: The quantitative assessment of accuracy indicated that the relative bias for the color chart ranged from -38% to 239% for the technical operator and -81% to 579% for the non-technical operator. The highest values were associated with sample concentrations near the detection limit. The relative bias for the Quick™ Arsenic Scan ranged from -93% to 99% for the technical operator and -86% to 66% for the non-technical operator. The overall agreement for the color chart results based on an assessment of whether the result was assigned to the correct color block indicated that the total percent agreement was 81% for the technical operator and 74% for the non-technical operator.

Precision: Precision was assessed by analyzing four replicates of each sample. For the technical operator, precision expressed as a relative standard deviation (RSD) ranged from 0% to 10% for the color chart and 5% to 23% for the Quick™ Arsenic Scan. For the non-technical operator, RSDs ranged from 0% to 23% for the color chart and 0% to 42% for the Quick™ Arsenic Scan.

Linearity: The linearity of response was evaluated by plotting the test kit results against the reference analysis results for the PT samples. The equations for the linear regressions that were performed to evaluate linearity are as follows, where x is the reference method concentration and y is the test kit concentration:

Color chart, technical operator	$y = 0.83x + 2.61$, R = 0.9992
Color chart, non-technical operator	$y = 0.90x + 2.78$, R = 0.9805
Quick™ Arsenic Scan #1, technical operator	$y = 0.85x + 0.83$, R = 0.9972
Quick™ Arsenic Scan #2, technical operator	$y = 0.87x + 0.41$, R = 0.9939
Quick™ Arsenic Scan #1, non-technical operator	$y = 0.68x + 0.99$, R = 0.9660

Method Detection Limit: The MDL was assessed by analyzing seven replicates of a sample spiked at a level approximately five times the manufacturer's estimated detection limit for the color chart (i.e., 3 ppb X 5 = 15 ppb). The MDLs calculated using the precision data from these replicates ranged from 3.1 ppb to 6.7 ppb for the color charts and 4.0 ppb to 7.2 ppb for the Quick™ Arsenic Scan.

Matrix Interference Effects: Results for samples containing low and high levels of interfering compounds (sodium chloride, sulfide and iron) indicated that low levels of interferents did not appear to affect the detection of arsenic; however, high levels of interferences appear to have affected the arsenic levels measured by the Quick™ Low Range test kit. Positive biases associated with these samples were higher than those measured for samples containing arsenic only.

Operator Bias: The color chart measurements made by the non-technical operator tended to be higher than for the technical operator, and the Quick™ Arsenic Scan measurements tended to be higher for the technical operator. Paired t-tests of the two sets of data indicated that the color chart results were not significantly different at a 5% significance level; however, the Quick™ Arsenic Scan results were significantly different for the two operators.

Inter-Unit Reproducibility: Inter-unit reproducibility was evaluated by comparing the data for the two Quick™ Arsenic Scan units used by the technical operator. A linear regression of the two sets of data indicated that the results closely corresponded. A paired t-test of the two sets of data indicated that the results were not significantly different at a 5% significance level.

Rate of False Positives/False Negatives: The rates of false positives and false negatives for the Quick™ Low Range test kit were assessed relative to the reference method using 10 ppb arsenic as the decision level. The rates of false positives for the technical and non-technical operators using the color charts were 3% and 12.5%, respectively. The rates of false positives for the Quick™ Arsenic Scan units were 3% and 0% for the technical operator (Units #1 and #2, respectively) and 3% for the non-technical operator (Unit #1 only). The false negative rates for the technical and non-technical operators using the color charts were 0% and 14%, respectively. The rates of false negatives for the Quick™ Arsenic Scan units were 19% and 14% for the technical operator (Units #1 and #2, respectively) and 9.5% for the non-technical operator (Unit #1 only).

Other Factors: The Quick™ Low Range test kits were easy to use and readily transportable to the field. The time to analyze one sample was approximately 15 minutes at a temperature range of 24°C to 30°C (longer reaction times are required for samples below this temperature range). Two samples were run concurrently without difficulty. The sample bottles were of moderate size and were relatively easy to handle, although the narrow neck sometimes caused spillage during the addition of reagents. The cost for a 50-sample test kit with the color chart is listed as $179.99. Replacement reagents and supplies are not available; kits are provided as a complete set because reagents, test strips, and color charts are made to perform optimally with each other, according to the vendor. The Quick™ Arsenic Scan is available as an option for an additional cost of $1,599.99.

signed by Gabor J. Kovacs	8/7/03
Gabor J. Kovacs	Date
Vice President	
Environmental Sector	
Battelle	

signed by Gary J. Foley	9/30/03
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VERIFICATION TEST DESCRIPTION

The Quick™ Low Range II test kit is an inexpensive, portable, rapid device designed for on-site analysis of arsenic in water. The Quick™ Low Range II test kit was verified in terms of its performance on the following parameters: accuracy, precision, linearity, method detection limit (MDL), matrix interference effects, operator bias, inter-unit reproducibility, and rate of false positives/false negatives. Results for two additional detection devices, the Quick™ Arsenic Scan and Compu-Scan, also were reported. All preparation and analyses were performed according to the manufacturer's recommended procedures. Results from the Quick™ Low Range II test kit were compared to those from the reference method to assess accuracy, linearity, and detection limit. Multiple aliquots of performance test samples and environmental samples were analyzed to assess precision. Matrix interference effects were assessed by challenging the test kit with performance test samples of known arsenic concentrations containing both low-level and high-level interferences. Identical sets of samples were analyzed independently by two separate operators (a technical and a non-technical Battelle staff member) to evaluate operator bias. All samples were analyzed using two Quick™ Arsenic Scan and Compu-Scan units to evaluate inter-unit reproducibility. False positives and negatives were evaluated relative to the 10-ppb maximum contaminant level for arsenic in drinking water. In addition to the analytical results, the time required for sample analysis and operator observations concerning the use of the test kit (e.g., frequency of calibration, ease of use, maintenance) were recorded.

Three types of samples were used in the verification test: quality control (QC) samples, performance test (PT) samples, and environmental water samples. The QC and PT samples were prepared from National Institute of Standards and Technology traceable purchased standards. The environmental water samples were collected from various drinking water and surface water sources. All samples were analyzed using the Quick™ Low Range II test kits and by a laboratory reference method.

QA oversight of verification testing was provided by Battelle. Battelle QA staff conducted a data quality audit of 10% of the test data, a performance evaluation audit, and a technical systems audit of the procedures used in this verification.

TECHNOLOGY DESCRIPTION

The optimal detection range for the Quick™ Low Range II test kit is below 15 ppb arsenic. Dilution instructions are provided for samples with arsenic levels above 8 ppb. The recommended temperature range for sample analysis is 24°C to 30°C. A modified testing protocol is available for sample temperatures below this range. To perform arsenic analyses with the Quick™ Low Range II test kit, the water sample to be tested is mixed in the supplied reaction vessel with reagent #1 (tartaric acid with rate enhancers) to acidify the water sample. Reagent #2, an oxidizer (potassium peroxymonosulfate), is added to remove hydrogen sulfide interference. The test tolerates up to 2 ppm hydrogen sulfide without interference. Zinc powder, reagent #3, is added to reduce inorganic arsenic compounds (As^{+3} and As^{+5}) to arsine gas. As arsine gas is generated and comes in contact with the test strip, the mercuric bromide indicator on the test strip changes color from white to shades of yellow or brown. Material Safety Data Sheets (MSDS) for all reagents and test strips are provided with each test kit. The MSDSs include information on how to safely handle the reagents and test strips, including instructions for exposure controls and personal protection.

Once the reaction is completed, the test strip is removed and visually compared to a color chart to obtain a semi-quantitative measure of the arsenic concentration in the tested sample. The color chart consists of a series of color blocks that correspond to concentrations ranging from 0.6 ppb to >100 ppb. The test strip may also be read with the Quick™ Arsenic Scan hand-held instrument, which operates on the same principle as a colorimeter and provides a quantitative result. The Quick™ Arsenic Scan is calibrated weekly using a calibration card provided by the manufacturer. Quantitative results may also be obtained from the test strip with a portable Compu-Scan scanner and laptop system. The scanned test strip image is converted to an arsenic concentration using the Home Port Computer System Arsenic Program Revision 5b software. The scanner is calibrated by the manufacturer. The Quick™ Arsenic Scan and Compu-Scan are not provided with the Quick™ Low Range II test kit as a standard feature. The standard test kit with the color chart was the subject of this verification test; however, results for the Quick™ Arsenic Scan and Compu-Scan were also provided. The test kits with the color charts are available in

sets of 50 tests with test strips provided in individually sealed packets. The typical shelf life of the kits is 24 months.

VERIFICATION OF PERFORMANCE

Accuracy: The bias for the Quick™ Low Range II color chart ranged from -92% to -8% for the technical operator and -74% to 74% for the non-technical operator. The bias for the Quick™ Arsenic Scan ranged from -98% to -27% for the technical operator and -76 to 9% for the non-technical operator. The bias for the Compu-Scan ranged from -93% to 104% for the technical operator and from -67% to 81% for the non-technical operator. The overall agreement for the color chart results based on an assessment of whether the result was assigned to the correct color block indicated that the total percent agreement was 45% for the technical operator and 38% for the non-technical operator.

Precision: For the technical operator, relative standard deviations (RSDs) ranged from 0% to 55% for the color chart, 0% to 84% for the Quick™ Arsenic Scan, and 7% to 91% for the Compu-Scan. For the non-technical operator, RSDs ranged from 0% to 15% for the color chart, from 9% to 67% for the Quick™ Arsenic Scan, and from 14% to 55% for the Compu-Scan. These results exclude samples where one or more of the replicate results was not detected by the Quick™ Low Range II test kit.

Linearity: The linearity of response was evaluated by plotting the test kit results against the reference analysis results for the PT samples. The equations for the linear regressions that were performed to evaluate linearity are as follows, where x is the reference method concentration and y is the test kit concentration:

Color chart, technical operator	$y = 0.79x - 0.03$, R = 0.9904
Color chart, non-technical operator	$y = 0.71x + 7.29$, R =0.9038
Quick™ Arsenic Scan #1, technical operator	$y = 0.42x + 0.29$, R =0.9619
Quick™ Arsenic Scan #2, technical operator	$y = 0.40x + 0.19$, R =0.9776
Quick™ Arsenic Scan #1, non-technical operator	$y = 0.71x + 2.45$, R =0.9826
Compu-Scan #1, technical operator	$y = 0.33x + 1.03$, R =0.9043
Compu-Scan #2, technical operator	$y = 0.40x + 3.05$, R =0.9063
Compu-Scan #1, non-technical operator	$y = 0.67x + 1.39$, R =0.9174

Method Detection Limit: The MDL was assessed by analyzing seven replicates of a sample spiked at a level approximately five times the manufacturer's estimated detection limit for the color chart. The MDLs calculated using the precision data from these replicates ranged from 1.2 ppb to 1.5 ppb for the color chart, from 0.7 ppb to 2.1 ppb for the Quick™ Arsenic Scan, and from 0.5 ppb to 3.9 ppb for the Compu-Scan.

Matrix Interference Effects: Low and high levels of interferents did not appear to affect the detection of arsenic. Biases for these samples were similar to those calculated for PT samples containing arsenic only.

Operator Bias: Measurements for the color chart, Quick™ Arsenic Scan, and Compu-Scan done by the non-technical operator tended to be higher than for the technical operator. A paired t-test of the two sets of data indicated that the results were significantly different at a 5% significance level.

Inter-Unit Reproducibility: The Quick™ Arsenic Scan results were more reproducible than the Compu-Scan results. Paired t-tests of the two sets of data indicated that the Quick™ Arsenic Scan results were not significantly different at a 5% significance level; however, the Compu-Scan results were significantly different.

Rate of False Positives/False Negatives: The false positive rates for the technical and non-technical operators using the color charts and Quick™ Arsenic Scan units were 0%. The rates of false positives for the Compu-Scan were 0% for both operators, except for Compu-Scan Unit #2, with a false positive rate of 3%. The false negative rates for the technical and non-technical operators using the color charts were 62% and 33%, respectively. The false negative rates for the Quick™ Arsenic Scan units were 62% for the technical operator (Units #1 and #2) and 38% for the non-technical operator (Unit #1). The false negative rates for the Compu-Scan were 67% and 52% for the technical operator (Units #1 and #2, respectively) and 9.5% for the non-technical operator (Unit #1).

Other Factors: The Quick™ Low Range II test kits were easy to use and readily transportable to the field. The sample bottles were of moderate size and were relatively easy to handle. The test kits were reliable. Analysis of diluted samples was sometimes difficult for the non-technical operator. Dilution of samples with arsenic concentrations exceeding the optimal detection range may be a source of error and reduce the accuracy and precision of the associated results because of the difficulty in performing accurate dilution in a field setting. The time to analyze one sample is approximately 15 minutes at a temperature range of 24°C to 30°C; longer reaction times are required for samples below this range. Two samples can be run concurrently without difficulty. The cost for a 50-sample test kit with a color chart is listed as $349.99. Replacement reagents and supplies are not available; kits are provided as a complete set because reagents, test strips, and color charts are made to perform optimally with each other. The Quick™ Arsenic Scan and Compu-Scan are available as options for an additional cost of $1,599.99 each.

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Vice President
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THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**ARSENIC TEST KIT**	
APPLICATION:	**ANALYSIS OF ARSENIC IN WATER**	
TECHNOLOGY NAME:	**Quick™ Ultra Low II**	
COMPANY:	**Industrial Test Systems, Inc.**	
ADDRESS:	**1875 Langston Street** **Rock Hill, SC 29730**	**PHONE: (803) 329-9712** **FAX: (803) 329-9743**
WEB SITE:	**www.sensafe.com**	
E-MAIL:	**its@cetlink.net**	

The U.S. Environmental Protection Agency (EPA) supports the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; with stakeholder groups that consist of buyers, vendor organizations, and permitters; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Advanced Monitoring Systems (AMS) Center, one of seven technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of portable analyzers for arsenic in water. This verification statement provides a summary of the test results for the Industrial Test Systems, Inc., Quick™ Ultra Low II test kit for measuring arsenic in water.

VERIFICATION TEST DESCRIPTION

The Quick™ Ultra Low II test kit is a portable, rapid device designed for on-site analysis of arsenic in water. The Quick™ Ultra Low II test kit was verified in terms of its performance on the following parameters: accuracy, precision, linearity, method detection limit (MDL), matrix interference effects, operator bias, inter-unit reproducibility, and rate of false positives/false negatives. All preparation and analyses were performed according to the manufacturer's recommended procedures. Results from the Quick™ Ultra Low II test kit were compared to those from the reference method to assess accuracy, linearity, and detection limit. Multiple aliquots of performance test samples and environmental samples were analyzed to assess precision. Matrix interference effects were assessed by challenging the test kit with performance test samples of known arsenic concentrations containing both low-level and high-level interferences. Identical sets of samples were analyzed independently by two separate operators (a technical and a non-technical Battelle staff member) to evaluate operator bias. All samples were analyzed using two Quick™ Arsenic Scan and two Compu-Scan units to evaluate inter-unit reproducibility. False positives and negatives were evaluated relative to the 10-ppb maximum contaminant level for arsenic in drinking water. In addition to the analytical results, the time required for sample analysis and operator observations concerning the use of the test kit (e.g., frequency of calibration, ease of use, maintenance) were recorded.

Three types of samples were used in the verification test: quality control (QC) samples, performance test (PT) samples, and environmental water samples. The QC and PT samples were prepared from National Institute of Standards and Technology traceable purchased standards. The environmental water samples were collected from various drinking water and surface water sources. All samples were analyzed using the Quick™ Ultra Low II test kits and by a laboratory reference method.

QA oversight of verification testing was provided by Battelle. Battelle QA staff conducted a data quality audit of 10% of the test data, a performance evaluation audit, and a technical systems audit of the procedures used in this verification.

TECHNOLOGY DESCRIPTION

The following description was provided by the vendor and does not represent verified information.

The optimal detection range for the Quick™ Ultra Low II test kit is below 4 ppb arsenic. Dilution instructions are provided for samples with arsenic levels above 4 ppb. The recommended temperature range for sample analysis is 24°C to 30°C. A modified testing protocol is available for sample temperatures below this range. To perform arsenic analyses with the Quick™ Ultra Low II test kit, the water sample to be tested is mixed in the supplied reaction vessel with reagent #1 (tartaric acid with rate enhancers) to acidify the water sample. Reagent #2, an oxidizer (potassium peroxymonosulfate), is added to remove hydrogen sulfide interference. The test tolerates up to 2 ppm hydrogen sulfide without interference. Zinc powder, reagent #3, is added to reduce inorganic arsenic compounds (As^{+3} and As^{+5}) to arsine gas. As arsine gas is generated and comes in contact with the test strip, the mercuric bromide indicator on the test strip changes color from white to shades of yellow or brown. Material Safety Data Sheets (MSDS) for all reagents and test strips are provided with each test kit. The MSDSs include information on how to safely handle the reagents and test strips, including instructions for exposure controls and personal protection.

Once the reaction is completed, the test strip is removed and visually compared to a color chart to obtain a semi-quantitative measure of the arsenic concentration in the tested sample. The color chart consists of a series of color blocks that correspond to concentrations ranging from 0.4 ppb to >25 ppb. The test strip may also be read with the Quick™ Arsenic Scan hand-held instrument, which operates on the same principle as a colorimeter and provides a quantitative result. The Quick™ Arsenic Scan is calibrated weekly using a calibration card provided by the manufacturer. Quantitative results may also be obtained from the test strip with a portable Compu-Scan scanner and laptop system. The scanned test strip image is converted to an arsenic concentration using the Home Port Computer System Arsenic Program Revision 5b software. The scanner is calibrated by the manufacturer. The Quick™ Arsenic Scan and Compu-Scan are not provided with the Quick™ Ultra Low II test kit as a standard feature. The standard test kit with the color chart was the subject of this verification test; however, results for the

Quick™ Arsenic Scan and Compu-Scan were also provided. The Quick™ Ultra Low II test kits are available in sets of 25 tests. The typical shelf life of the kits is 24 months.

VERIFICATION OF PERFORMANCE

Accuracy: The bias for the Quick™ Ultra Low II color chart ranged from -78% to 18% for the technical operator and -87% to 45% for the non-technical operator. The relative bias for the Quick™ Arsenic Scan ranged from -91% to 22% for the technical operator and -95% to 16% for the non-technical operator. The relative bias for the Compu-Scan ranged from -80% to 161% for the technical operator and -92% to 70% for the non-technical operator. The overall agreement for the color chart results based on an assessment of whether the result was assigned to the correct color block indicated that the total percent agreement was 70% for the technical operator and 57% for the non-technical operator.

Precision: For the technical operator, precision expressed as a relative standard deviation (RSD) ranged from 0% to 55% for the color chart, 2% to 51% for the Quick™ Arsenic Scan, and 6% to 85% for the Compu-Scan. For the non-technical operator, RSDs ranged from 0% to 84% for the color chart, 4% to 78% for the Quick™ Arsenic Scan, and from 11% to 139% for the Compu-Scan.

Linearity: The linearity of response was evaluated by plotting the test kit results against the reference analysis results for the PT samples. The equations for the linear regressions that were performed to evaluate linearity are as follows, where x is the reference method concentration and y is the test kit concentration:

Color chart, technical operator	$y = 0.92x + 0.22$, R = 0.9948
Color chart, non-technical operator	$y = 0.87x + 4.45$, R = 0.9498
Quick™ Arsenic Scan #1, technical operator	$y = 0.91x + 0.04$, R = 0.9830
Quick™ Arsenic Scan #2, technical operator	$y = 0.81x + 0.55$, R = 0.9934
Quick™ Arsenic Scan #1, non-technical operator	$y = 0.70x + 2.51$, R = 0.9700
Compu-Scan #1, technical operator	$y = 1.15x - 0.88$, R = 0.9980
Compu-Scan #2, technical operator	$y = 1.93x - 3.82$, R = 0.9946
Compu-Scan #1, non-technical operator	$y = 1.03x + 3.99$, R = 0.9322

Method Detection Limit: The MDLs calculated using precision data from seven replicates of a low-level spiked sample ranged from 2.9 ppb to 3.1 ppb for the color chart, 2.8 ppb to 2.9 ppb for the Quick™ Arsenic Scan, and 4.7 ppb to 5.4 ppb for the Compu-Scan.

Matrix Interference Effects: Low and high levels of interferents did not appear to affect the detection of arsenic. Biases for these samples were similar to those calculated for PT samples containing arsenic only.

Operator Bias: No apparent difference was observed in the color chart and Compu-Scan results for the technical and non-technical operators. Measurements for the Quick™ Arsenic Scan done by the technical operator tended to be higher than for the non-technical operator. A paired t-test of each data set indicated that the results were not significantly different at a 5% significance level for the color chart and Compu-Scan, but were significantly different for the Quick™ Arsenic Scan.

Inter-Unit Reproducibility: The results for the Quick™ Arsenic Scan closely corresponded; however, the results for Compu-Scan Unit #2 tended to be higher than the results for Unit #1. Paired t-tests of the two sets of data indicated that the Quick™ Arsenic Scan results were not significantly different at a 5% significance level. The Compu-Scan results for the two systems were significantly different.

Rate of False Positives/False Negatives: The false positive rates for the color charts were 0% for both operators. The false positive rates for the Quick™ Arsenic Scan units were 6% and 3% for the technical operator (Units #1 and #2, respectively), and 3% for the non-technical operator (Unit #1). The false positive rates for the Compu-Scan units were 16% and 25% for the technical operator (Units #1 and #2), and 9% for the non-technical operator (Unit #1). The false negative rates for the technical and non-technical operators using the color charts were 14% and 24%, respectively. The false negative rates for the Quick™ Arsenic Scan units were 29% and 24% for the technical operator (Units #1 and #2) and 57% for the non-technical operator (Unit #1). The false negative rates for the Compu-Scan units were 24% and 19% for the technical operator (Units #1 and #2) and 48% for the non-technical operator (Unit #1).

Other Factors: The Quick™ Ultra Low II test kits were easy to use and readily transportable to the field. The time to analyze one sample is approximately 15 minutes at a temperature range of 24°C to 30°C; longer reaction times are required for samples below this range. Two samples can be run concurrently without difficulty. The sample bottles were relatively easy to handle. Dilution of samples with arsenic concentrations exceeding the optimal detection range may be a source of error and reduce the accuracy and precision of the associated results because of the difficulty in performing accurate dilution in a field setting. The cost for a 25-sample test kit with color chart is listed as $299.99. Replacement reagents and supplies are not available; kits are provided as a complete set because reagents, test strips, and color charts are made to perform optimally with each other, according to the vendor. The Quick™ Arsenic Scan and Compu-Scan are available as options for an additional cost of $1,599.99 each.

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linearity, method detection limit, matrix interference effects, operator bias, and rate of false positives/false negatives. All preparation and analyses were performed according to the manufacturer's recommended procedures. Results from the Quick™ test kit were compared to those from the reference method to assess accuracy, linearity, and detection limit. Multiple aliquots of performance test samples and drinking water samples were analyzed to assess precision. Identical sets of samples were analyzed independently by two separate operators (a technical and a non-technical Battelle staff member) to test for operator bias. Matrix interference effects were assessed by challenging the test kit with performance test samples of known arsenic concentrations containing both low-level and high-level interferences. False positives and negatives were evaluated relative to the recently established 10-ppb maximum contaminant level for arsenic in drinking water. In addition to the analytical results, the time required for sample analysis and operator observations concerning the use of the test kit (e.g., frequency of calibration, ease of use, maintenance) were recorded.

Three types of samples were used in the verification test: quality control (QC) samples, performance test (PT) samples, and environmental water samples. The QC and PT samples were prepared from National Institute of Standards and Technology traceable purchased standards. The environmental water samples were collected from various drinking water and surface water sources. All samples were analyzed using the Quick™ test kits and by a laboratory reference method. Every tenth sample was analyzed twice by the reference method to document the reference method's precision.

QA oversight of verification testing was provided by Battelle. Battelle QA staff conducted a data quality audit of 10% of the test data, a performance evaluation audit, and a technical systems audit of the procedures used in this verification.

TECHNOLOGY DESCRIPTION

The Quick™ can be used to test for total arsenic in water. The vendor indicates that up to 2.0 mg/L of hydrogen sulfide is tolerated without test result interference, and up to 5 parts per million of antimony is tolerated. The Quick™ consists primarily of two reaction bottles, two caps for holding the test strip, three spoons, three bottles of reagent, and one bottle of arsenic test strips in a waterproof, plastic case. The three reagents are added sequentially to the water sample and shaken. A test strip is placed into the turret of the cap. The test strip is exposed to arsine gas evolved from the sample solution, resulting in a color change in the test strip. When the reaction is complete, the test strip is compared with a color chart provided with the kit. The intensity of the yellow/brown color developed on the test strip relative to the color chart is proportional to the arsenic concentration in the sample and, therefore, provides a semi-quantitative analysis of the arsenic concentration. The color chart consists of the gradations: 0, 5, 10, 20, 40, 60, 100, 200, 300, and 500 parts per billion (ppb). In a few cases, the operator interpolated between gradations to estimate the arsenic concentration. The kits are available in three sizes: for two tests, 50 tests, or 100 tests.

VERIFICATION OF PERFORMANCE

Accuracy: An assessment of quantitative accuracy of the Quick™ showed that percent bias values ranged from 8 to 83% for the non-technical operator and 8 to 84% for the technical operator for the individual PT samples. The percent bias ranged from 8 to 92% for the non-technical operator and 8 to 54% for the technical operator for the drinking water samples. For the freshwater samples, the percent bias ranged from 2 to 320% for both the non-technical and the technical operator. An additional criterion for accuracy was the percentage of samples for which the Quick™ result was within 25% of the reference result or within a corresponding "less than" range. By this criterion, the Quick™ yielded a qualitative accuracy for the PT samples of 71% for the non-technical operator and 55% for the technical operator. The qualitative accuracy for the drinking water samples was 57% for the non-technical operator and 52% for the technical operator. The qualitative accuracy for the freshwater samples was 96% for the non-technical operator and 54% for the technical operator.

Precision: Seven of the 14 replicate sets for the PT samples showed a relative standard deviation (RSD) of 0%, i.e., all results were identical. The remaining replicate sets for the non-technical operator had an RSD ranging from 29 to 50%, and the remaining replicate set for the technical operator had an RSD of 29%. For the drinking

water samples, the RSDs for the non-technical operator ranged from 29 to 100%, and the RSDs for the technical operator ranged from 0 to 18%.

Linearity: The linearity of response of the Quick™ was assessed using the PT samples containing 2 to 112 ppb arsenic. The linear regression for the Quick™ results for the non-technical operator was ppb = 0.90 (±0.086) x (reference, ppb) - 5.2 (±4.1) ppb, with a correlation coefficient (r) of 0.974. The corresponding equation for the results for the technical operator was ppb = 0.88 (±0.056) x (reference, ppb) - 0.45 (±2.7) ppb, with a correlation coefficient (r) of 0.988.

Method detection limit: The manufacturer's estimated detection limit for the Quick™ is 5 ppb. A total of seven replicate PT samples were analyzed at a concentration of 25 ppb. The non-technical operator reported arsenic between 5 and 20 ppb, the technical operator reported all seven replicates at 20 ppb. Since the Quick™ test kit is only semi-quantitative, no MDL was calculated from these data.

Matrix interference effects: The Quick™ showed a minor tendency toward higher readings (3 ppb on average) with higher levels of sodium chloride, iron, sulfide, and acidity. Because of the study design, it was not possible to determine which ion was responsible for the observed result.

Operator bias: The operator skill level does not appear to be a major factor determining Quick™ results.

Rate of false positives/false negatives: The rates of false positives and false negatives for the Quick™ were assessed relative to the reference method using 10 ppb of arsenic as the decision level. The rate of false positives for the Quick™ was 4% for the non-technical operator and 0% for the technical operator. The rate of false negatives was 16% for the non-technical operator and 5% for the technical operator.

Other factors: The Quick™ is available in three sizes, with the smallest being capable of analyzing two samples at a cost of $12.99. The 50-sample test kit costs $79.99. The large kit, capable of analyzing 100 samples, sells for $139.99. The Quick™ allows two samples to be analyzed simultaneously. The total reaction time is less than 15 minutes. The reagents are ready to use with no preparation required. Three scoop sizes are included in the Quick™, making addition of the reagents simple, but the size and shape of the reaction containers limit the ease of use of the kit. This kit requires no liquids or concentrated acids, making it safe and easy to carry in the field. The solid reagents contain no toxic materials.

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